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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · APRIL 25, 1960

They made it slide on air... see page 3

DEPENDABILITY, ECONOMY and STRENGTH are distinguishing characteristics of these sintered metal automotive transmission parts by Delco Moraine. Vital components such as these are typical results of close collaboration between Delco Moraine and its customers—an effective liaison that operates from idea through design and development. They also attest to Delco Moraine's equally important capabilities for making deliveries in quantity and on time!

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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

April 25, 1960 Vol. 31, No. 17

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How the gleam of Nickel Stainless Steel can give your products sales appeal

When you make your product of *Nickel* Stainless Steel, you give it important advantages in today's competitive market.

You give it the advantage of product quality—the lustrous beauty, outstanding serviceability, freedom from corrosion, and ease of cleaning that consumers prefer.

In addition, you give your product the benefit of promotion such as shown above, in which stainless steel housewares are featured in department store displays and in national advertising.

Consumer preference for Nickel Stainless Steel products is further insured through research, engineering, and technical service to fabricators, which results in constantly improved quality and greater customer satisfaction.

The basic beauty and serviceability of this gleaming metal, combined with preference-building activities by Inco and stainless steel producers and manufacturers, are why products of Nickel Stainless Steel will have an increasing edge in the market place of the '60's.

Why not consider Nickel Stainless Steel for *your* product? ©1960, T.I.N. Co., Inc.

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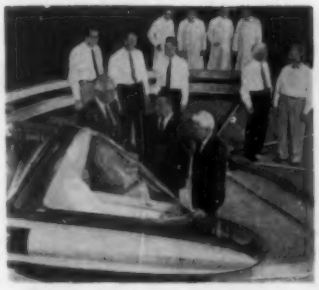
TO INSURE PLENTIFUL NICKEL for stainless steel and other uses, Inco-Canada is developing a mine in Manitoba to step up Inco-Canada's capacity to 385,000,000 lbs a year. This will boost Free World projected nickel output to over 650,000,000 lbs in 1961—an all time high, and 60% more than the 1959 Free World consumption. Above: headframe of new mine.

INTERESTING TO NOTE

". . . with the Greatest of Ease"



Our cover shows some of the men responsible for the design and development of Ford Motor Co's Levacar. Standing directly behind the experimental vehicle are, left to right: Dr Andrew A. Kucher, vice-president, engineering and research; David J. Jay, Levacar project manager; and Robert J. Saxon, aeronautic engineer. Behind them stand research and design engineers; in the back row are four Ford technicians. Although development of the Levacar began at Ford about five years ago, Dr Kucher first conceived the principle of a vehicle sliding on air some 30 years ago, at a time when he was interested in airplanes.

Basically, there are three groups of wingless, air-supported vehicles: Those lifted by reaction to a jet, those supported by a blanket of low-pressure air, and those supported by a thin film of relatively high-pressure air (see news roundup, p 15). The Levacar falls in the third category. Air-cushion vehicles attain heights of several feet, but Levacars are limited to bare fractions of an inch. Nor can they operate over rough land or water; in fact, all design projections are based on twin-rail systems similar to today's trains. However, while limited in mobility to tracks (a monorail system also could be employed, although it doesn't look as attractive as twin rails), Levacars are capable of much higher speeds, currently estimated at about 500 miles an hour.

The supports, called "levapads," can be designed in any shape and size, and do not occupy the entire width of the vehicle, as air-cushion low-pressure systems do. Therefore, levapad design has little influence on the minimum width of the vehicle, meaning Ford could design long, slender, highly streamlined single-unit Levacars with passenger capacities comparable to today's planes and trains.

The power requirement for Levacars is roughly 1/6th that required for vehicles supported by an air jet and ⅓ to ½ that needed for low-pressure air-cushion types. Design studies are now underway for a 4-passenger Levacar that will have its own power supply for both levitation and propulsion and its own braking system. It will be ready for test within two years.

Although the Levacar is still in the experimental stage, one car-kit manufacturer, (the AMT Corp) is already marketing a scale replica. It's built of plastic and actually can move across the floor, supported on a column of air.

What's New in School?

Throughout history the form and content of the school curriculum have been in a constant state of change. Schoolboys in ancient Athens took stiff courses in Homer, mathematics, gymnastics and music. The ancients thought the study of music put one's soul in harmony with the universe,

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a belief which persisted for almost 1000 years. In neighboring Sparta, however, students were taking courses in swimming, fighting and stealing (it developed the future soldier's ingenuity).

In the colonies of Massachusetts and New Haven 300 years ago, the law specified that all children and apprentices be taught to read, but said nothing about writing. It was not uncommon to find colonial schoolmasters who read well, but wrote badly or not at all. In China, on the other hand, learning was the only route to power until well into the 20th century. The civil servants who ran the country had to pass exams that included a test of their ability to write poetry.

Today the contrast seems to be between the Soviet system and our own. On page 57 an article gives samples of tests that Soviet students must pass before being admitted to college. The Soviets are highly enthused about education. US enthusiasm seems directed elsewhere. New York State feels bound to pay its race track steward twice what it pays its head of education. New Yorkers spent 33 million dollars for the fanciest race track in the world (not unlike the great Hippodrome which Rome built shortly before its fall) but can't afford to replace antiquated school buildings. True, if we compared this country's beautiful horse-ovals with Soviet's large, rococo, unimaginative university buildings, we'd win that race by several lengths.

Bearings the Size of Flies' Eyes

When a jeweler says a watch needs a new mainspring, he usually knows what he's talking about. However, when a jeweler in Lebanon, NH told Winslow S. Pierce that the silver-cased pocket watch his father had given him was not worth repairing, the young Yankee saw red. His sense of values could not understand why a good watch is ready for the ash heap simply because one of the 14 jewels has cracked. Why couldn't he make his own bearing to replace the cracked jewel?

Pierce did just that. He first made midget tools to cut the tiny races. But in tempering them, he couldn't pass the races over heat without warping. He solved this problem by dropping them through the flame into a pan of oil. Using a jeweler's loupe, he honed and polished parts to an accuracy of 0.0005 of an inch. When he was finished, Pierce inserted 10 tiny balls between the races and shipped his broken watch with the new bearing to a New York jeweler for installation. The watch worked perfectly and Pierce forgot about his new bearing development.

But word spread about the miniature-bearing worker in New Hampshire and in time Pierce received requests from around the world—a physics professor needed a tiny bearing for a project he was working on; a polar expedition needed an oil-free camera bearing for arctic temperatures. Pierce eventually had so many orders that he founded a company to manufacture his tiny product. Although he died in 1950, his company (Miniature Precision Bearings Inc) is still making the smallest bearings in the world. An article discussing integral ballbearings (p 47) comes from the chief engineer of MPB's Split Ball Bearings Div. —Benedict A Leerburger, Jr

NEXT WEEK IN PRODUCT ENGINEERING

. . . **Electrical Analogs Simplify Heat-flow Analysis**
These simulators need only batteries, resistors and capacitors.

. . . **Shaping Vulcanized Fibre Parts**
Describes nine methods, tells what influence they have on design.

. . . **Which Copper Alloy?**
For cold-heading applications, this ready-reference chart shows choice is wider than you may think.

. . . **When to Specify Centralized Lubrication**
Eight factors that determine whether it is preferable to point-to-point manual methods.

. . . **6 Ingenious Jobs for Roller Chain**
How this industrial workhorse can be harnessed in a variety of ways to perform tasks other than simple power-transmission.

. . . **5 Experiments in Technical Writing**
Basic "rules" of writing are put to test. Some are true; others are not.

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HEAT and GASKETS

Heat can affect the performance of resilient gasket materials. Its effects can be minimized, however, by proper selection of materials and special consideration of certain mechanical aspects of the joint.

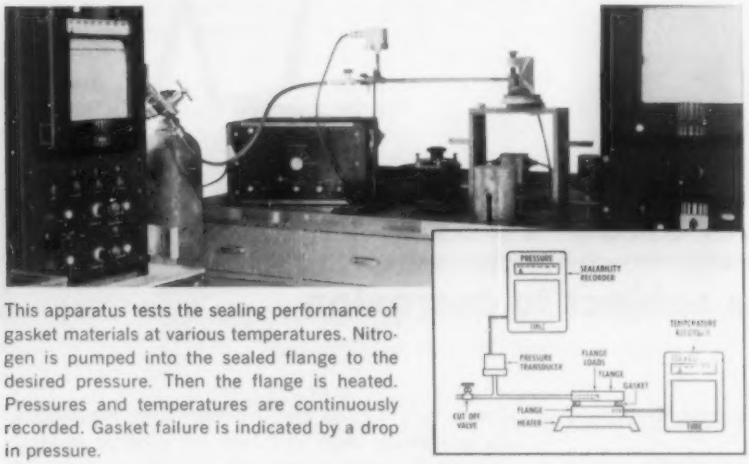
E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

Where resilient gasket materials will be used at temperatures substantially higher than room temperature, the possible effects of heat must be considered.

Actually, heat is less of a limiting factor than is commonly supposed. By knowing the range of temperature limits of the various classes of materials (see table), a designer may be able to find a resilient gasket that meets his temperature requirements just as well as a more expensive material.

Resilient gaskets usually are organic, and exposure to high temperature can cause physical damage such as charring . . . or it may volatilize the fugitive binders of some plant fiber materials. Such damage will, of course, eventually result in leakage. It usually can be avoided by staying within recommended temperature limits of the material or by using an inorganic gasket such as Armstrong asbestos Accopac.

A more subtle effect of heat—and one more difficult to detect—is the softening it tends to produce in almost any nonmetallic gasket. Because of plastic flow or some form of fatigue, high temperatures act to reduce the ability of a resilient gasket to maintain flange pressures over relatively long periods. The result can be serious loss of bolt torque.



This apparatus tests the sealing performance of gasket materials at various temperatures. Nitrogen is pumped into the sealed flange to the desired pressure. Then the flange is heated. Pressures and temperatures are continuously recorded. Gasket failure is indicated by a drop in pressure.

This torque loss can be minimized by using rigid flanges that can impose adequate flange loads on the gasket; and by selecting a gasket material with good torque retention properties (see table). The Armstrong Accopac line contains a number of asbestos fiber materials which have excellent torque retention characteristics.

Class of material	Maximum sustained temperature at gasket line*	Rank in order of torque retention
Asbestos	750° F.	1
Cellulose	300° F.	2
Cork-and-rubber	250° F.	3
Straight rubber	250° F.	4
Cork composition	250° F.	5

* These are recommended design limits. Obviously, in many applications temporary exposure to higher temperatures can be tolerated. Consideration should also be given to nature of contained fluids, since some fluids which are inert at room temperature become more active as temperatures increase.

Checking the effects of heat is just one part of a continuous test program on gasket materials at our Research and Development Center. The experimental apparatus shown at left is one of many similar devices used to study the behaviors of gasket materials under a wide variety of laboratory and simulated service conditions.

The Armstrong Gasket Design Manual contains additional data on the effects of heat as well as much other detailed information on the design, selection, and performance of resilient gasket materials. Write for your free copy today to Armstrong Cork Company, Industrial Division, 7104 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

1860–1960 Beginning our second century of progress

DEVELOPMENTS TO WATCH...

Metal tape for magnetic recording

To meet the demand for high-strength, high-temperature tape for new magnetic recording instruments, American Silver Co is readying two new materials—thin metal foils to serve as carriers for magnetizing layers, and dual-purpose foils made of high-permeability alloys that can be magnetized themselves.

First of the metal tapes to reach the commercial market will likely be an 0.001- or 0.000,75-in. phosphor bronze coated with a magnetic oxide. The high-permeability tapes are not as far along in development, but American Silver confidently predicts that they are on their way.

New source for high-tensile wire

Carbon-steel wire that will have a guaranteed tensile strength of 575,000 psi is now in pilot production at National-Standard Co, Niles, Mich, and will soon be available in commercial quantities. Initial production will be in the 0.004-in.-dia size, but other sizes are planned for later introduction. Samples are now available for evaluation.

Terminals punch but do not pierce

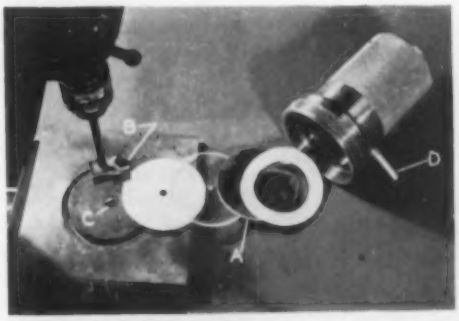
Terminals that will penetrate but not pierce through plastic circuit boards are being introduced by Three Point One Four Corp, Yonkers, NY. The units are basically hollow tubes, so designed that they will flare at a predetermined depth and, once seated, will withstand a 50-lb pull. The terminals can be made of almost any material, the company says, and the external portion of the unit can be designed to fit almost any application. The first units—of half-hard brass—are now going into production. Full technical data will be available within the next few weeks.

New test for abrasion proposed by zinc researchers

How much wear on machine parts results from abrasion by inks, paper slurries, and similar materials? A test proposed by R. D. Fraik and F. C. Schmultz of New Jersey Zinc Co gets the answer by measuring weight loss when standard metal samples are abraded.

Basic components of the tester are the metal samples, a felt-wrapped abrading block, and a slurry containing the abrasive material.

The abrasive cell (see photo) is mounted in a drill press which holds and rotates it against the surface being tested.



TEST EQUIPMENT includes drill press (left) which holds abrading block (B); disk-shaped metal specimen (A); abrasion cell with slurry outlet (D). Slurry enters system through hole (C) beneath drill spindle.

By choosing the metal to correspond with that of specific machine parts, a good correlation was obtained with actual service experience. For their tests, aimed at solving papermaking and printing problems, the NJZ men are using copper disks to simulate printing press plates, and steel disks for trimmer blades.

Different abrasives (tile, titanium dioxide, clay), they say, give consistently different results on the different metals. Talc, for instance, causes 4 to 5 times as much wear on brass and copper as on steel; while clay has the opposite effect.

Fraik and Schmutz have prepared a report on the test, which is being readied for publication by the Technical Assn of the Pulp & Paper Industry.

Capacitors for 1000 F, coatings for 2000 F—with silicon nitride

Thin, nonporous films of pure silicon nitride vapor-deposited on molybdenum substrates are making it possible to produce capacitors that maintain satisfactory dielectric properties to 1000 F and above, say C. R. Barnes and C. R. Geesner of Wright Air Development Center. Furthermore, they report in a paper prepared for the Electrochemical Society, such coatings offer a convenient and effective method for protecting metal surfaces from atmospheric oxidation at temperatures approaching 2000 F.

Although this particular report is based specifically on work with molybdenum as the substrate, there is indication that similar results can be achieved with other metals.

Britons develop improved metal coats

Methods for obtaining better chrome plates on zinc diecastings, and improved hot-tin coatings for small parts like eyelets, tags, and terminals, are announced in England.

The chrome-plating system, worked out by the British Non Ferrous Metals Research Assn, is claimed to produce coatings 2 to 3 times as thick as those previously obtainable without cracking; and, says BNFMRA, "the extra corrosion resistance of this improved coating is quite remarkable even though the chromium is still less than 0.0001 in. thick." The secret: careful control of current density and temperature. Details are given in BNFMRA development Report No 62, an 18-page printed booklet, available from the association, Euston St, London, NW1. British price: 7/6d (about $1.05).

As to tin coatings, the Tin Research Institute says research on hot-tinning methods for small parts in bulk has progressed to the point where "it is now possible to make definite recommendations to industry"; and methods for coating copper strip at speeds of 1000 ft/min., and for high-speed coating of steel strip, are in development.

More metals to be stockpiled for the space age

At least three new materials will be added to the stockpile list if the recommendations of the National Academy of Sciences Committee on Materials Research (*PE*—Apr 4, p 12) are followed. The three: rhenium, tantalum, tellurium.

The reasons: potential future uses in high-temperature structures, electronic equipment, thermoelectric devices.

Another material worth watching: protactinium. It's element 91, a radioactive metal so rare almost nothing is known about it. It has a melting point well above 5000 F.

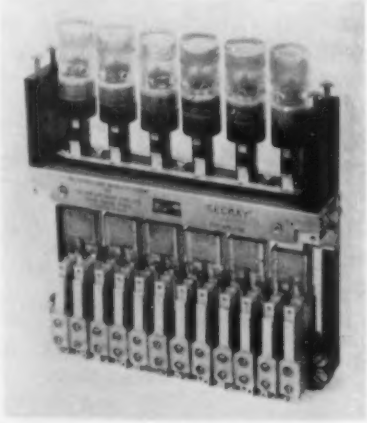
Pushbutton switch designed in England

A multiple-button switch that provides adjustable make-before-break action on any button and features high mechanical and electrical reliability has been designed by Seton Creaghe Engineering Ltd, London NW 10.

The system is so arranged that operation of contacts can be adjusted from break-before-make to make-before-break, and operation of any one button can be made to release any other button.

Seton Creaghe plans to produce the unit with a standard arrangement of two double-pole changeover contacts, in multiples of 2 buttons (up to 16) at ¾-in. spacing. Contacts are of a 40% silver-palladium alloy, contact springs are phosphor bronze, and major wearing components are nylon-coated. Contact rating is 250 ma at 50 volts dc.

Price is expected to be on the order of $7.70 per button. —ARG



PRECISION-BANKED SWITCH features positive-action latching and release mechanism, adjustable to make-before-break.

WHAT'S HAPPENING IN RESEARCH . . .

Shock waves can make metals glow

Aluminum plates can be made to give off light when hit by a shock wave, Naval Ordnance Lab researchers report.

"When a shock wave emerges from the free surface of an illuminated aluminum plate," they told a local-section American Physical Society meeting, "blue light is emitted from the surface."

Their explanation: emission from the electron color centers in the aluminum oxide coating.

The light played on the surface, they theorize, ionizes these color centers, causing electron emission and the generation of a surface charge. Since the shock wave represents a power surge of approximately 10^9 watts/cm^2, it drags out a "sheet" of electrons by an electroacoustic effect. Then, when these electrons reach the surface oxide layer, they are accelerated, excite the electron centers, and cause blue-light emission.

More coatings to serve as electrical components

Resistors, rectifiers and heating elements with better mechanical, electrical, and thermal properties are promised by research now in progress with new semimetallic films.

From the Ukraine, for instance, comes a report that ac rectifiers suitable for use at temperatures to 250 F and showing rectification coefficients of 20,000 or more, can be made using vapor-deposited cadmium iodide films on a copper substrate. And, say the Soviets, performance and mechanical strength of the film can be still further improved by superposing a thin layer of mercury iodide. With this layer, rectification coefficients as high as 5×10^4 have been achieved.

In this country, research is centering on silicides, nitrides, and oxides of the transition metals.

Among the most promising of these are chromium-titanium nitride, which produces hard, abrasion-resistant refractory films showing desirable temperature and electrical coefficients, and chromium-silicon coatings, which can be made to exhibit a wide range of resistance coefficients by varying the temperature of the substrate on which they are deposited.

Another compound that rates close attention is indium oxide. Battelle Memorial Institute reports it has a resistivity in the semiconductor range, can be deposited in film form at relatively low temperatures (below 400 F) and has a high optical transmittance that makes it seem suitable for transparent heating elements.

In their present stage of development, most of these still present fabrication problems, and a good deal remains to be learned about their properties. But, says Battelle, "the need for the improved or unique properties they exhibit should provide the impetus for developing production techniques."

Ceramic heat exchangers under test

Can problems of corrosion and heat resistance be overcome by using alumina tubes in place of metal for high-temperature heat exchangers? Bureau of Mines researchers are exploring the possibility. The primary aim: to develop equipment for high-temperature gascooled nuclear-process heat reactors.

Studies so far have been made only with single-tube units, using vitreous alumina as the material of construction and helium gas as the heat-transfer medium.

At inlet-gas temperatures of 1450 to 2665 F, encouraging results were recorded; and, said S. C. Browning and J. S. Sebastian of the Bureau of Mines, "ceramic heat exchangers show considerable promise at higher temperatures." However, they are limited to low pressures and "their technical feasibility depends on developing reliable gastight seals and eliminating high thermal stresses."

Liquids proposed for thermoelectric conversion

Liquid thermoelectrics rate consideration for applications beyond the range of present-day materials, says Dr C. M. Kelley of Stanford Research Institute.

As he points out, the design goal of nuclear reactor heat exchangers and a good many other new power systems is on the order of 3500 F—far beyond the range of conventional thermoelectrics; and there are other applications that will call for temperatures in the same range. True, gaseous thermocouples have been developed (*PE—Dec 1 '58, p 10*); but he believes liquids, including molten germanium, tellurium, and cuprous sulfide deserve consideration.

The thermoelectric power of properly chosen liquids, he says, can be greater by a factor of at least 100 than that of most metals. He has calculated energies and entropies of vaporization for a number of possible materials, and believes additional studies would be well worthwhile.

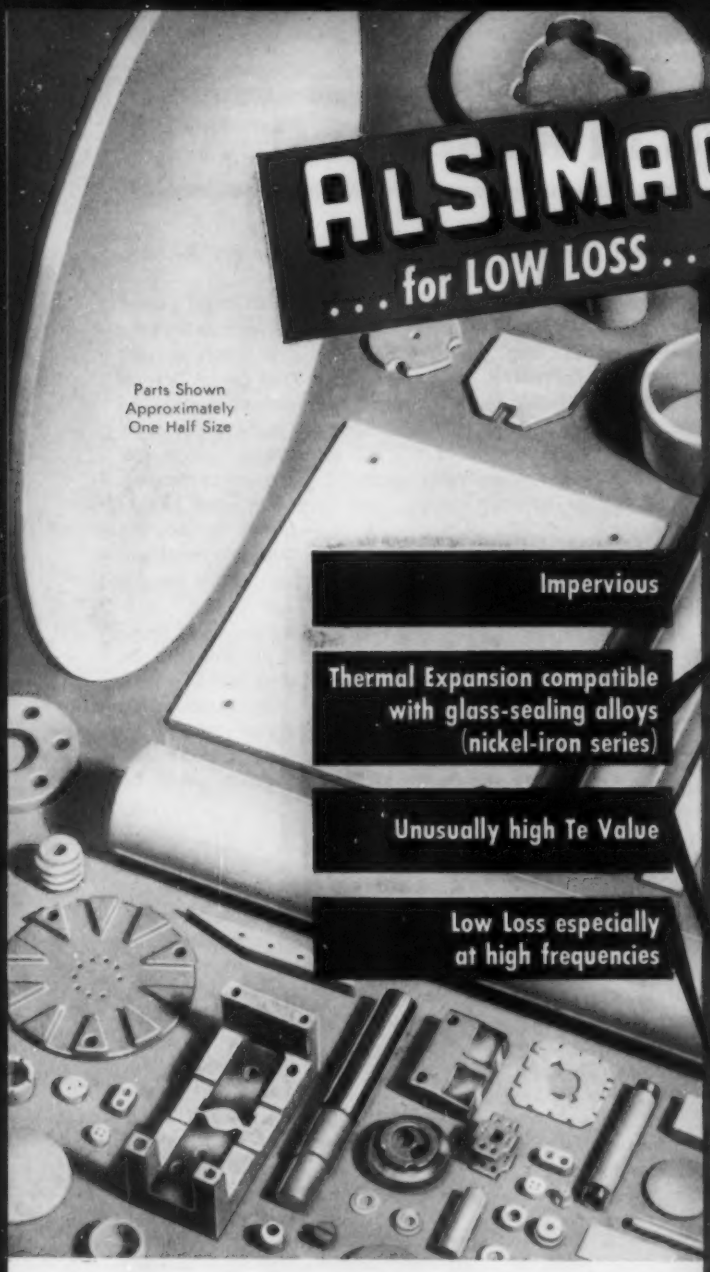
New mixer for the lab

A unit specifically designed for mixing small batches of explosive liquid-solid combinations and other hard-to-handle materials is being offered by Atlantic Research Corp, Alexandria, Va. Made of thick-walled stainless steel and fitted with a heavy glass or acrylic plastic observation port, it is a sigma-blade unit similar to a larger machine introduced by the company several years ago. The new one will handle samples weighing from ½ to 2 oz (25 to 50 gm) and is designed for rapid disassembly and easy cleaning. The price: $2385. —ARG

BABY MIXER is patterned after larger units; is ruggedly built to handle explosive compounds.

ALSIMAG 243

. . . for LOW LOSS . . . for HERMETIC SEALING



Parts Shown Approximately One Half Size

Impervious

Thermal Expansion compatible with glass-sealing alloys (nickel-iron series)

Unusually high Te Value

Low Loss especially at high frequencies

Note These Advantageous Properties

PROPERTY	UNIT	AlSiMag 243
Water Absorption	%	0 to .02 Impervious
Specific Gravity	———	2.8
Density	Lbs. per cu. in.	.101
Standard Body Colors[a]	———	Buff
Softening Temperature	°C. °F.	1 440 2 624
Safe Temperature at Continuous Heat	°C. °F.	1 000 1 832
Hardness	Mohs' Scale[b]	7.5
Thermal Expansion Linear Coefficient	Per °C. 25-300°C. 25-700°C.	10.0×10^{-6} 11.2×10^{-6}
Tensile Strength	Lbs. per sq. in.	10 000
Compressive Strength	Lbs. per sq. in.	85 000
Flexural Strength	Lbs. per sq. in.	20 000
Resistance to Impact (½" rod)	Inch-Lbs.	4.0
Thermal Conductivity[c] (Approximate Values)	g. cal. x cm. thick cm^2 x sec. x deg. C.	.008
Dielectric Strength (step 60 cycles) Test discs ¼" thick	Volts per mil	240
Volume Resistivity at Various Temperatures 25°C.	Ohms per centimeter cube	$>10^{13}$
100°C.		5.0×10^{13}
300°C.		7.0×10^{11}
500°C.		1.2×10^{10}
700°C.		1.0×10^{9}
900°C.		3.0×10^{8}
Te Value[d]	°C. °F.	>1 000 >1 832
Dielectric Constant[e] 60 Cycles	———	6.3
1 MC.		6.2
100 MC.		6.1
10,000 MC.		5.8
Power Factor[e] 60 Cycles	———	.0014
1 MC.		.0004
100 MC.		.0003
10,000 MC.		.0010
Loss Factor[e] 60 Cycles	———	.009
1 MC.		.002
100 MC.		.002
10,000 MC.		.0058

The low loss, Te value and thermal expansion characteristics of Forsterite ceramics are not equalled by any other impervious ceramic. This is especially important when high frequencies or sealing to metals or glasses is involved.

These properties have created a steadily increasing demand for AlSiMag 243. In the past two years major improvements have been made on this material and its fabrication. We are now producing components formerly unattainable in this material and the number of applications is constantly increasing.

If your application requires the favorable characteristics of AlSiMag 243, why not send us your blue prints and outline your operating conditions? If it is possible that your requirements can be met, we will be glad to work with you at reasonable cost on prototypes for your practical tests. Test discs approximately 1/2" x 3/32" are available with our compliments.

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58TH YEAR OF CERAMIC LEADERSHIP

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All other export: Minnesota Mining & Manufacturing Co., International Division, 99 Park Ave., New York, N. Y.

Easy to install! Easy to service! Hard to wear out!

LINK-BELT "RC" COUPLINGS

Here's a flexible coupling that's ✓simple ✓dependable ✓inexpensive

SIMPLE! Link-Belt "RC" couplings consist of two sprocket halves joined flexibly with a piece of roller chain. The chain is specially constructed for flexible coupling service—it is of single width construction, but has extra overall width and *divided rollers* which provide independent contact with each sprocket tooth . . . equalize load . . . compensate for shaft misalignment. Especially important, "RC" couplings are easy to install . . . easy to take apart and put together.

DEPENDABLE! Chain and sprocket halves are made of quality steel. In addition, sprocket teeth and chain parts are hardened. The resulting *extra* strength and wearability pays off in long, dependable service.

INEXPENSIVE! Extremely simple design holds down the cost of "RC" couplings.

HARDENED WEARING SURFACES of both chain and sprocket add extra wear-life to "RC" couplings.

CHOICE OF HOUSINGS

— for retention of lubricant and protection of the coupling. Style R — spun metal, vertical split. Style P — molded plastic, horizontal split.

FULL DETAILS are contained in Book 2363. For your copy, call your nearest Link-Belt office, listed under COUPLINGS in the yellow pages of your phone book.

LINK-BELT

"RC" FLEXIBLE COUPLINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,158-A

FROM WASHINGTON . . .

Army needs quiet engine for foxhole warfare

The National Inventors Council wants a silent-running power source. Such an engine is needed by the Army to power electric generators and propel boats in front-line areas.

The engine must be inaudible at a distance of 1000 ft under fairly quiet conditions. The immediate need is for portable engines in the 6- to 10-hp range. Larger engines are needed too.

Over-all weight of a 10-hp engine should not exceed 150 lb. Cost is secondary to size and performance of the engine, the council says. The noise level of the engine will be checked by a panel of 10 people, rather than by a decibel rating.

Development contracts will be let for proposals that have merit. Proposals should be submitted to Leonard Hardland, National Inventors Council, US Dept of Commerce, Washington 25, DC.

NASA grip on patents loosened by House Space Committee

The patent policy of the National Aeronautics and Space Administration has been reversed by the House Space Committee. The measure must still get an okay by the Senate, however.

On a 14-to-4 vote, the House group approved an amendment to the Space Act that would allow contractors to keep patent rights stemming from research contracts. The government would still get royalty-free use, however.

Industry has opposed the patent provisions of the Space Act since it was enacted in 1958. And NASA officials admit they are having trouble placing contracts. Companies now are denied patent rights unless NASA grants special dispensation.

Companies with patent advantages in space work shy away from NASA contracts, the agency says. Reason is the companies don't want to jeopardize the patent advantage they already hold. Also, since most of the larger companies also do work for the Pentagon, where they are allowed to keep patent rights, the companies bog down in a patent dilemma trying to operate under two systems.

Under the House amendment, NASA would have authority to change the patent provisions on existing contracts. The patent amendment, however, is sure to be well scrutinized by the Senate. The Senate Patents Subcommittee under Sen C. O'Mahoney (D-Wyo) has spent two years trying to work out a uniform patent policy for all government agencies, and the subcommittee may object to piecemeal changes coming now.

Commerce Dept asked to upgrade technology

A team of experts from the National Academy of Sciences has recommended establishing an Office of Assistant Secretary for Science and Technology within the US Dept of Commerce.

This special advisory committee recommends that the assistant secretary be an official "with professional and management experience in science and technology." The committee also calls for specific expansions of agency programs in science and technology. The new assistant secretary would be responsible for activities of the Bureau of Standards, the Office of Technical Services, the Patent Office, the Coast and Geodetic Survey, and the Weather Bureau. He would also be concerned with R & D activities of the Maritime Administration and the Bureau of Public Roads.

Veeder-Root READOUT Bulletin

One of a Series

New "White Room" Assembly Insures Accuracy, Reliability of Instrument Counters

This special facility has been designed to provide positive environmental control for ultra-precision assembly and test of Veeder-Root Instrument Counters. Temperature and humidity are constant and electrostatic filtering and pressurization maintain air purity.

This is the latest step taken by Veeder-Root to insure top reliability and accuracy in counters and readout devices used for instrumentation, aircraft and navigational applications. Veeder-Root offers an extremely varied line of these instrument type counters; and also does extensive design and prototype work to develop new devices for all types of readout problems. Whatever your needs for precision counting devices, Veeder-Root can provide that extra margin of dependability by supplying a single counter or complete counting package or system. Your specifications will receive prompt attention.

Veeder-Root Precision Gearing Provides Long Life, Accuracy at High Speeds

The secret of Veeder-Root precision counter performance is the close tolerance manufacturing and inspection of gearing, typified by the strip chart record shown here. This Veeder-Root experience with all types of intricate gearing, to Precision Class 2 tolerances, assures accuracy and dependability in readout devices and counting packages.

Send for More Information . . . or advise your precision counter requirements. Application assistance is available from Veeder-Root Counting Engineers or write.

Veeder-Root

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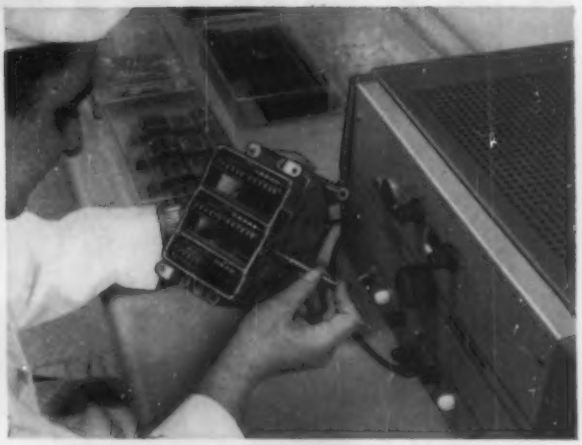


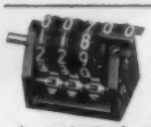
This is a Veeder-Root Counting Package developed for airborne navigational systems. It is being assembled and tested in the new "white room".

Series 1597 Miniaturized Counter

designed for readout of navigational data. Features maximum figure size on ⅛" wheel, plus small overall dimensions and light weight. For high speed counting.

Series 1698 Internal Pinion Counter

developed for aircraft instrumentation such as altimeters, fuel readout and manifold pressure. Wheels are only 0.672" in diameter.

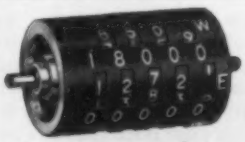


Series 1392 Open Frame Counters

for navigational computers. Has extremely low torque, wheels are ball-bearing mounted, and counter is available with various frame styles for mounting into "packaged" systems.

Series 1666 Precision Internal Pinion Counter

available with 3 or 4 figure wheels, in single or tandem styles. Minimum size, maximum readability.



Series 1387 and 1388 Concentric Drum Counter

for latitude and longitude readout. These counters offer compact digital presentation, speeds to 300 rpm, and unusually long counting life.

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☐ Please send Precision Counter Data Sheets
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Culminating five years of intensive research, engineers of The United States Graphite Company have developed a new oxidation resistant GRAPHITAR. In exhaustive tests, GRAPHITAR parts were exposed in an oxidizing atmosphere (air) at 1200 degrees F and after 200 hours, the GRAPHITAR showed a weight loss of less than six percent!

GRAPHITAR, which is available in many grades, is a versatile engineering material with unusual and outstanding properties that make it ideal for tough applications. It is non-metallic, resists chemical attack, has self-lubricating properties and a low coefficient of friction. It is mechanically strong, lighter than magnesium and is the perfect material for packing rings, pressure joint seals, clutch release bearings, fluid coupling seals, piston rings, pump liners and vanes.

For more information on this new oxidation resistant GRAPHITAR and its applications, write the GRAPHITAR product manager on your company letterhead.

R-279-1

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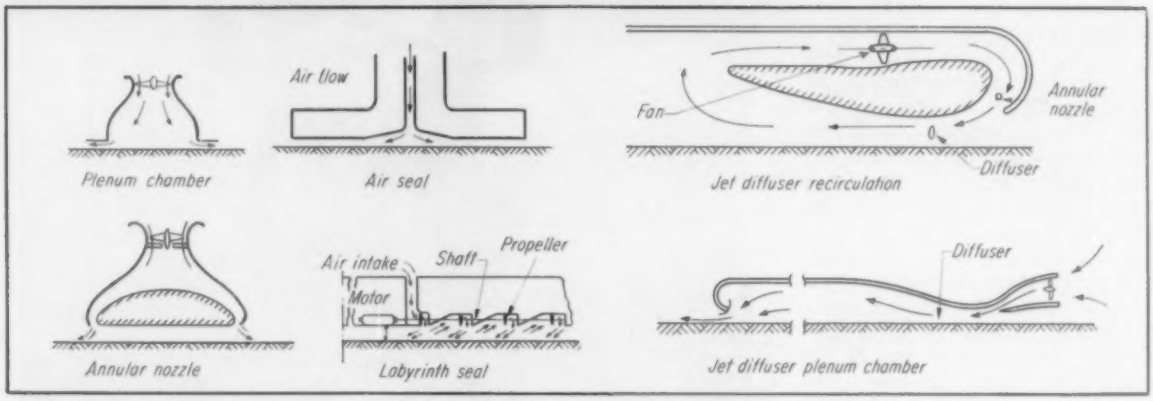
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

THE ENGINEERING WEEK



Developers of ground-skimming machines are seeking a model that is efficient, dependable and capable. Here, courtesy of Hiller Aircraft, are drawings of five rival configurations. (A sixth major type, the ram wing, is not shown.) PRODUCT ENGINEERING, with added data from McGraw-Hill World News bureaus, find that . . .

Ground-effect Machines Are Promising—But Need Lots More R & D

NEW YORK—The wheel and rudder will undoubtedly be around for a long time. But the technical advantage of operating a vehicle just above the ground, where it can profit from the ground-cushion effect, is catching the imagination of a good many engineers. And because the tactical advantages of such a vehicle—which can operate with equal ease over water, swamp or land—is catching the interest of the military, these engineers are widely engaged in research and development programs.

The ground-cushion effect has been recognized for many years. Aircraft, helicopters, flying platforms and even birds display increased efficiency during the brief period when they are close to the ground. But until a few years ago, proposals for ground-effect machines (GEM's) designed solely to exploit this phenomenon were few.

The increased efficiency of a GEM occurs because it experiences lift beyond that provided by engine thrust alone—air forced beneath the craft is trapped there and exerts a back pressure on the bottom of the vehicle. Hence, lift is a combination of back pressure and thrust. The ground effect tapers off with altitude—most GEM's now travel at maximum altitude of 5% of their diameter. GEM's have other advantages too. They are, for example, free of ground drag.

Of the many configurations proposed to make the most of the ground cushion, most experts believe that the one ultimately holding most promise for wide commercial and military development is the annular jet. A second and simpler type is the plenum chamber. A few companies are offering commercial versions of the plenum, but at present it appears to have inherent limitations compared with the annular jet. Other competing concepts include the ram wing conceived by T. V. Kaario of Finland, the Levapad of Ford Motor Co. the diffuser chamber of Hiller Aircraft and the labyrinth seal of Switzerland's Carl Weiland.

A PROMISING CONCEPT

Experimental data now available indicate that the annular jet can attain higher altitudes than the plenum chamber with equal bottom area, weight in vehicles and horsepower. In the jet type, an engine-fan combination blasts air from the top of the craft down through a duct that circles its periphery. As this air rushes out the bottom of the vehicle, it raises pressure between the craft and the earth until the jet stream is bent toward the outside air. The jet thereby acts as a flexible curtain to maintain air pressure beneath the craft. Generally, the duct inside the GEM points the jet inward at the bottom to gain better lift-to-thrust ratio.

Much of the research on these vehicles is still in the theoretical stage and, where hardware exists, it is often wrapped in military or proprietary secrecy. But a few experimental models do exist. In this country, Princeton Univ, under contract with the US Army, has built an experimental GEM that is circular in planform, 20 ft dia, and weighs 1075 lb gross. Lift and thrust for the craft, which has attained an altitude of about 14 in. and speed of 25 mph, are produced by a 43-hp Nelson motor. Thrust—forward, sideward or backward—is obtained by opening or closing four sets of vents

Some US Companies Working on GEM's

Annular Jet
- Gyrodyne Co. of America
- Aerophysics Corp.
- North American Aviation, Inc.
- Bertelsen Mfg. Co., Inc.

Plenum Chamber
- Bell Heliocopter Corp.
- Curtiss-Wright Corp.
- Spacetronics, Inc.

Diffuser
- Hiller Aircraft Corp.

Levapad
- Ford Motor Co.

Feasibility & Theoretical Studies
- Ryan Aircraft
- Convair Div., General Dynamics Corp.
- Rand Corp.
- Aeronautics Div., Ford Motor Co.
- Douglas Aircraft Co., Inc.
- McCulloch Corp.
- Vehicle Research Corp.
- National Research Associates, Inc.
- Lockheed Aircraft Corp.

space, around the craft. Directional control is given by a tail rotor with 5-hp engine.

The hovercraft of England's Saunders-Roe was originally supposed to be a plenum chamber, but it metamorphosed into a twin-jet system. Internal bracing for the plenum chamber was reportedly inefficient. Saunders-Roe engineers switched to a single annular jet, which they found unstable, then to a twin annular jet. Distance between the two jet rings was twice the expected hovering altitude of the vehicle. According to available information, the craft that crossed the English Channel weighed 9300 lb gross, had a bottom area of 535 sq ft and max speed of 23 knots. The original proposal called for a 450-hp Alvis Leonides engine driving a horizontal fan. The company recently announced that the hovercraft will be fitted with a Turbomeca Marbore turbine engine for additional forward thrust. At present the propulsion system requires about ⅓ of the engine power.

ONE-MAN GEM, built for the Bureau of Naval Weapons by Gyrodyne Co. was designed with high funnel contour so that air ducts bend gradually, allowing faster air-exit speeds. From tests next summer, Gyrodyne hopes to get needed and detailed aerodynamic data.

PLENUM CHAMBERS

The much less sophisticated plenum chamber has been described as an upside-down bath tub. A fan-engine combination drives air into the enclosed space, raising internal air pressure. When the plenum chamber rises, some of the air leaks out around the bottom.

Curtiss-Wright has had considerable publicity for its Air-Car, based on this principle, and has found a purchaser for two—the US army. The Air-Car comes in two models. The larger is 21 ft long, 8 ft wide and weighs 2800 lb with fuel load, according to company sources. It is powered by two 180-hp engines which drive it at 60 mph. Hovering altitude is 12 in. During forward travel at high speed, altitude may run as low as 6 in. The company also has in development stage an over-water version with gross weight of 51,500 lb, driven by engines delivering a total of 1780 hp. This model is said to be 87 ft long, and capable of cruising at 28 knots over calm water.

Another near-commercial plenum is the one-man scooter of Bell Helicopter, for which the company is now negotiating a limited manufacturing agreement. Envisioned primarily as a sports or amusement park craft in its present form, the unit is 85 in. long, 53 in. wide, weighs 160 lb, and is driven by a 14-hp motor. Directional control is supplied both by louvers and shifting of the driver's weight.

LABYRINTH SEAL

Carl Weiland, working as an engineer with the Federal Aircraft Works of Emmen, Switz., developed the labyrinth seal. Its purpose, Weiland says, is to seal in more of the air that has been forced beneath the craft. This would reduce air consumption—and the equipment required to move air. The labyrinth is a series of chambers around the circumference of the craft. Air, which has been pulled beneath

ANNULAR JET EXPERIMENTAL VEHICLE, developed at Princeton's Forrestal Research Center, has planform resembling a sea ray—and has been so nicknamed. The four radial air slots on bottom of the craft are yielding basic information on stability problems, according to T. E. Sweeney of the Dept of Aeronautical Engineering.

LATEST ADDITION TO THE LEXICON OF BARRIERS is the "spray barrier" which Carl Weiland's vehicle broke on Lake Zurich last summer. Shown here just before her trip, the Ilen reached speeds of 58 mph. At 36 mph, the spray—which normally shrouds such ground-cushion vehicles—disappeared and water surface became hard.

the craft, flows outward toward the chambers. At the chambers, the airstream divides, part being sucked into the chamber by the fan and part continuing its outward flow. Air in the chambers is ducted back to the main stream. When the two streams meet, eddies form and air flow is considerably reduced.

Weiland has constructed a ship, the Ilen, based on this configuration. Last February the ship reportedly traveled at nearly 60 mph on Lake Zurich. It is 35 ft long, 30 ft wide, weighs 7 tons, and has engines that produce 700 hp. The Ilen has been sold to the US Navy and is presently scheduled for trials on the Potomac River. Weiland has also obtained manufacturing rights with a shipbuilding company in the United States.

DIFFUSERS

Another configuration advanced to reduce air consumption, hence power, is the diffuser-recirculation chamber of Hiller Aircraft. Hiller is working on both annular jet and plenum chamber versions. The annular diffuser-recirculation concept is analogous to an open-throat wind tunnel: Air is recirculated to conserve power. Lift is provided by a horizontal jet. But unlike conventional annular jets, the air, instead of being turned out, is diffused by an obstruction between the ground surface and lower GEM surface to produce static pressure. Theoretically, this air can be recirculated to intake fans, but Hiller engineers realize that in practice some will escape and have to be replaced. They have not yet contemplated forward motion for this concept.

In the diffuser-plenum version, air is taken in at front of the GEM and exhausted at the rear. A diffuser amidships creates static life pressure. Forward thrust is integral with such a concept. Hovering capability could be introduced with two or more open plenum chambers.

AIR-BEARING TYPE

Air-bearing GEM's were envisioned by Dr Andrew Kucher of Ford about 30 years ago. This concept differs markedly from the others in that the vehicle travels over a rail but is separated from it by a tissue-thin film of air (*PE—Mar 7, p 16*). Key to the system is the "Levapad" which fits over the rail and from which very high-pressure air emerges. In theory, Levacars may attain speeds of 200 to 500 mph. But the gain in speed is achieved with loss of mobility. Applications will probably be limited to mass-transportation systems.

RAM WING

Granddad of the GEM's is the ram wing, which was conceived by T. J. Kaario of Tampere, Finland in 1932 and has been under development by him ever since. It is a concave configuration—like a wing that operates close to the ground. Air, driven underneath by a fan, is held by the trailing edge of the wing. Major advantages of his configuration, says Kaario, is its stability at high speed. Other engineers, he says, apparently believe that their vehicles must always travel at less than critical speed (speed at which dynamic loading equals wing loading). But his tests, he says, have been run at higher speeds.

His ram wing has good power economy as well, he explains. As the vehicle gains speed, flow from the rear produces forward propulsion, and flow at front is retarded by dynamic pressure of forward speed until it turns in. At this point, front and rear portions require very little assistance from the power system. And flow from side can be directed in such a way as to reduce drag.

WHITHER GEM'S

There is no shortage of ideas on how these vehicles can be used. The ideas range from the heroic to the whimsical. An engineer with David Taylor Model Basin has drawn plans for a ferry to ply the Chesapeake; a Midwestern physician, Dr William R. Bertelson, sees applications as a sort of ambulance-auto for serving out-of-way patients. (He has constructed several models.) Princeton engineers contemplate the possibility of an airplane that can take off from a ground cushion in lieu of paved runways. Douglas Aircraft is experimenting with a glide-air system for moving luggage from terminals to aircraft on air-cushion pallets. And McCulloch Motors has even dabbled in ground-effect armchairs for easing the moving of executives around their offices.

But despite advances in this technology, most investigators are convinced that a great deal of basic research is yet needed before practical applications are found—if ever.

One of the most perplexing problems is stability. GEM's behave reasonably well at heights up to about 5% of their diameter. Beyond that the ability of the craft to level itself after being tilted is seriously impaired. Because of this, many engineers believe that GEM's will be most suitable for large ocean-going craft whose bottom areas are large enough for them to travel over waves. Researchers at Univ of Calif, however, have found that a 50-ft GEM would be as helpless as a 50-ft boat in rough waters because of air turbulence caused by variations of wave height and frequency.

Not all engineers, however, are willing to concede that a small craft on land will inevitably have to detour around such obstacles as fence posts and rocks. Basic studies such as those at Princeton are seeking to understand why instability occurs—hoping that with this knowledge, stability may be built into GEM's at higher altitudes.

A second problem is to get better directional control without sacrificing low-horsepower advantages. These airborne craft are controlled by aerodynamic forces and therefore sluggish compared with the quick corrective response of tires. Slow directional response is a greater handicap over land than water. But controls drain engine hp—and more controls require larger engines. ■

Economists Predict Changes in R & D Growth

NEW YORK—Already a major US industry, R & D expenditures are mounting and may well reach $22 billion in 1969, according to the McGraw-Hill Department of Economics. The department notes, however, that doubling of R & D expenditures in the 1960s will be at a slower growth rate than experienced in the last decade when funds for research quadrupled from $3.1 billion in 1949 to $12 billion last year.

McGraw-Hill's economists further predict that striking changes in purposes and source of support for R & D will become evident in the Sixties. A smaller proportion of the total effort, they say, will be supported by gov-

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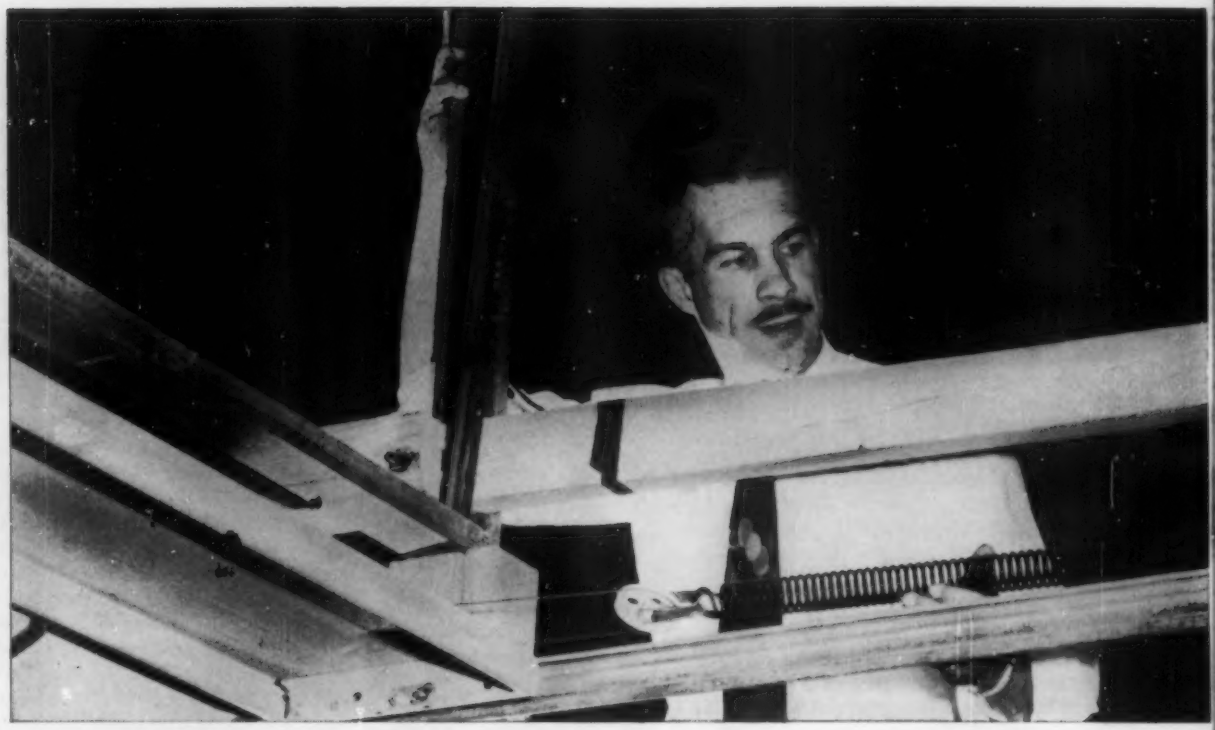
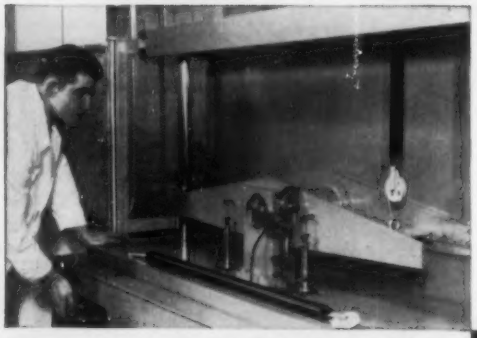


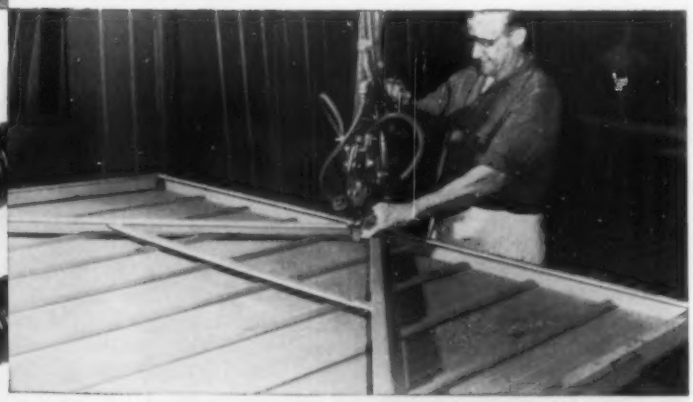


At Steel Door . . .

USS American Springs

thanks to AS&W

In the American Steel & Wire Fatigue Laboratory, a technician runs tests on a USS American Spring, designed for Steel Door use. On the basis of this test a change in hook design was recommended to give longer spring life.



A Steel Door workman assembles a Berry One-Piece Door. This company uses steel exclusively for all doors because of its many consumer advantages. Steel is stable, won't warp or swell. Steel doors need less maintenance and preparation, and steel doors are easy to operate.

This close-up shows the improved hook on the extension springs supplied by American Steel & Wire for the Steel Door overhead garage doors.

stretched 31,000 times and still going strong...

Spring Engineering Research Service

The Steel Door Corporation, Birmingham, Michigan, is the world's largest manufacturer of residential garage doors. For the production of these doors they use about 150,000 USS American Springs every year. Steel Door asked American Steel & Wire for a statistical evaluation of the fatigue life of the extension hook-type springs they use. The AS&W Spring Engineering Research Service tested these springs in the Fatigue Laboratory and recommended a change in hook design.

So successful was this design change that the life of the springs has been materially increased. At the Steel Door plant a cycle test was set up using USS American Springs on an overhead door. At the present time these springs have completed over 31,000 cycles without showing any sign of failure. This is the equivalent of 25 years of normal usage.

Mr. Ralph Qualman, Advertising Director and Service Manager, says: "It is extremely important that the springs—especially those used on sectional doors where the strain is greatest—have proper tension and a long life. American Steel & Wire supplies Steel Door with springs that meet their engineering specification and life expectancy."

If you have a spring problem or would like advice on the use of springs in your product, get in touch with our general offices in Cleveland, or any American Steel & Wire Sales Office. You can benefit from the knowledge of AS&W's Spring Engineering Research Service. The Service has been engaged in laboratory experiments of static and dynamic testing for 20 years and has accumulated invaluable data on stress and fatigue life of steel springs, while endeavoring to improve efficiency in the use of steel—from steel chemistry through product application—to more economically cope with today's rigorous demands. This accumulated knowledge of the AS&W Spring Engineering Research Service is at your disposal. *American Steel & Wire, 614 Superior Ave., N.W., Cleveland 13, Ohio.* *USS and American are trademarks*

American Steel & Wire Division of USS **United States Steel**

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • Tennessee Coal & Iron Division, Fairfield, Ala., Southern Distributors • United States Steel Export Company, Distributors Abroad

continued from page 17

ernment; more by industry. They also predict a decreased emphasis on product development and increased emphasis on applied and basic research.

In industry, the forces behind the research boom are still strong. But, henceforth, industry will have to do more scientific digging for payoff products. Much of the older supply of applied research has been carried through to development, the economists say.

In both government and industry-support R & D, a marked shift from product development to applied and basic research is predicted, though product development will remain predominant. The more basic work is likely to get about 40% of funds in '69, compared with 30% in '59. ■

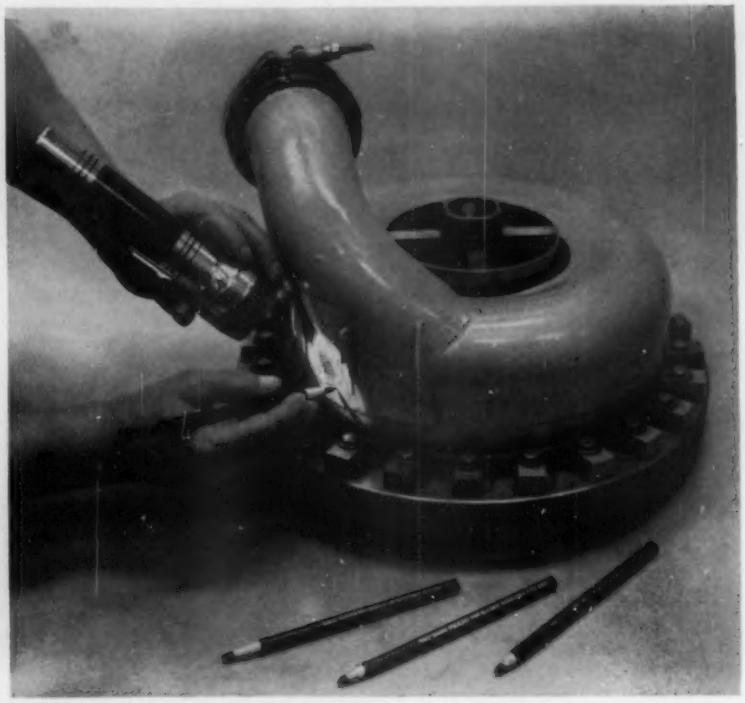
Welding Benefits from Pulse-power Method

DETROIT—A new resistance-welding technique that delivers a high-voltage, high-current pulse for every half cycle (120 times a second with 60-cycle current) has been developed here by Robotron Corp for welding-machine manufacturers.

Now in the testing stage, the new system applies power in short, high-intensity bursts. Peaked current and delivered voltage are 2 to 5 times those of normal resistance welding, according to Robotron engineers, who add that efficient utilization of current reduces heat losses in the transformer. Result: a 75% smaller transformer has been designed.

The new "spike power" technique is applicable to a wide variety of materials, including all combinations of brass along with stainless, galvanized, aluminized and terneplate steels. Other materials successfully welded are copper to copper and to brass; copper-plated steel to copper-plated steel (without destroying the plate), aluminum to aluminum, and magnesium to magnesium. One application now in development is the welding of zinc to zinc, normally difficult because of zinc buildup on the electrodes.

The technique will be shown publicly for the first time at the American Welding Society Show, Los Angeles, April 26-28. ■



CRACKED-LACQUER AREAS ARE OUTLINED with color crayons in Hamilton Standard's stress tests. Each stress level gets its own color code; after maximum stress is reached, a color photo records the stress patterns.

Record Stress Levels on Color Film

ROCHESTER—Using color film instead of black-and-white for experimental stress measurement can save a precision-equipment maker about $20 per print, or as much as $25,000 a year, reports Eastman Kodak Co.

At Hamilton Standard Div of United Aircraft, the part to be tested is sprayed with a resin-type lacquer which dries in 24 hr. When the part is loaded, the lacquer covering develops cracks perpendicular to the strain in the surface of the metal. Extent of the cracked area is marked with a colored wax crayon (see photo). Later, as additional crack patterns appear with increased loading, the patterns become load contours drawn on the parts.

During the tests, calibration strips sprayed with the same brittle lacquer are stressed by specific amounts to determine the stress-strain relationship of the coating.

After the highest load has been applied, the part is photographed from many different angles for the permanent, workable record. Color prints of the pictures enable the stress-analysis engineers to compute the stress distribution for the various load contours.

Formerly black-and-white prints were hand-colored, costing as much as $21 more than the color photo. According to Hamilton Standard engineers, the color prints also serve as a valuable sales tool for indicating general quality of the product. ■

Bill Will Spur Scientific Effort

WASHINGTON—Congressman Dominick Anfuso (D-NY) has introduced three pieces of legislation which he hopes will stimulate greater scientific effort in the US. His bills provide for:

A $10,000 award to national Medal of Science winners.

Creation of a commission to coordinate scientific activities.

Establishment of a national space control agency to ensure that all exploration and utilization of outer space will be for peaceful purposes. ■

AEC Tries to Lure Engineers with Education

WASHINGTON—The Atomic Energy Commission is developing a basic atomic-reactor training program, to attract young engineers to AEC employment.

An education and training committee is now acting on the commission's request to put together an atomic engineering curriculum that would provide graduates just out of engineering schools—but with no background in atomic energy—with sufficient nuclear know-how, at least, to start in careers with the government's atomic agency.

The training program is being fashioned because:

- AEC is rapidly losing scientific and engineering manpower.
- Top-notch young graduates apparently need more than AEC's starting GS-5 ($4940 a year—top of the pay grade) salaries to lure them.

The attrition in AEC's scientific personnel is generally conceded to be due to higher paying jobs and better working conditions offered by industry.

To recruit engineers, graduating in the upper third of their class, for the special training programs, the Civil Service Commission has granted AEC the privilege of offering GS-7, or $5880-per-year starting salaries. With this concession, weekly salary of the trainee would average slightly over $100 per week—AEC feels this is on a par with current wages offered by industry. An engineer recruit must undergo a stiff security investigation, or "Q" clearance, for handling top secret work, and as a further condition, he must agree to remain with AEC for no less than 30 months after completion of training.

The special training program will begin in July and last 18 months—9 of classroom work and laboratory instruction at Oak Ridge or Argonne National Laboratories, and 9 of on-the-job training in AEC area-operations offices.

The seven such offices charged with recruiting aspects of the program are located at New York; Savannah River, Ga; Chicago; Oak Ridge, Tenn; Idaho Falls; Hanford, Wash; and San Francisco, Calif.

The trainee-engineers will fill reactor-project engineering positions on construction jobs related to civilian power reactors and under AEC administration in the field. None is slated for desk jobs in AEC's Washington headquarters.

About 30 trainees are to be recruited for the July start, and those who will round out the group are now being interviewed by the field offices.

Personnel people handling the program have misgivings about the program's underlying philosophy. Recruiting officials contend that AEC should hire individuals holding at least a master's degree, with nuclear working experience. But AEC simply can't get people with master's and PhD degrees at salaries paid by the government. ■

Dice-size Electronic Components Save Weight, Space

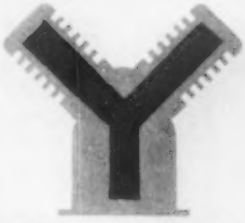
Modular card being held replaces 23 conventional printed circuit boards on table. Half-in.-cube units, weighing 2 gm. have a package density of 44 to 50 per card—smallest general-purpose computer presently available holds an equivalent 8 to 10 modules per card. According to Republic Aviation's Missile Systems Div, the modules are suited for use in any all-purpose digital computer, although initially designed for the guidance system of the "Swallow" reconnaissance drone. Packaging density is a ¼ million parts per cu ft. Silicon semiconductor components are expected to perform reliably in a temperature range from —70 to 240 F. Encapsulating material gives excellent heat conduction, besides sealing the circuit against moisture.

INTRODUCING: THE ALL-NEW

WORTHINGTON X COMPRESSOR is the newest, most modern air-cooled compressor on the market. The X shape has been achieved by a short stroke design with reduced cylinder overhang and by use of a wide stance base.

WORTHINGTON X COMPRESSOR

I-SHAPE compressor is prone to harmful vibration in both horizontal and vertical planes as the two pistons travel up and down in opposite directions. Cooling is also a problem. Only one cylinder is in the direct path of cooling air from the compressor fan and there is about 40% less cooling surface.



Y-SHAPE increases cooling by spreading cylinders. The vibration problem, however, is only partially solved. Pistons operating at 45 degrees to horizontal tend to rotate the compressor. When supported by a small, narrow base the unit tends to be unstable and prone to harmful vibration.

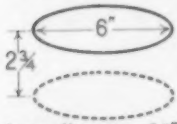
X-SHAPE compressor gives excellent cooling plus minimum vibration. The same twisting forces occur as the pistons move back and forth but this compressor with its wide stance base is more stable. As a result, there is less internal strain, and vibration is considerably reduced.

New design reduces vibration—enemy of compressor life

Vibration is the mortal enemy of every reciprocating machine. Sooner or later vibration must exact its toll in the form of wear or failure. Controlling vibration is the secret of building compressors that run longer and quieter with less maintenance.

Our new X compressor was designed to be the most "rock steady" unit on the market. *Vibration is so negligible that we have balanced a coin on an X compressor while it was running.*

The story behind this first air cooled compressor redesign by a major manufacturer in 15 years is interesting.



Our engineers started with a modern short stroke, large bore design. (A typical cylinder has a diameter of 6"; stroke of only 2¾".) This design reduces piston travel and wear, and increases efficiency.

The short cylinders that resulted made it possible to reduce cylinder overhang considerably. Then the width of the base was increased until an X shape was obtained.

Concurrently, the decision was made to operate at higher rotative speeds. This reduced size and weight. The X design is 15% to 20% smaller and lighter than most compressors. The X compressor was designed to operate up to 1750 rpm (versus a top of 900 or so for most other units.) Its short stroke design, however, makes piston speeds very conservative. They never exceed 700 feet per minute.

The new X compressor has many other innovations. Its silicon treated filter element is 99%+ efficient. Its shell-molded, ductile iron crankshaft has better balance and greater strength. Its aluminum connecting rods increase heat conductivity and reduce reciprocating weight. In all, more than 25 separate innovations were incorporated in the design.

The new X compressor is equipped with Worthington's famous Feather* valve. The lightest, fastest-acting valve in the industry, the Feather valve has compiled an outstanding performance record. (A recent survey indicates that operating men prefer them two to one over the next nearest type).

Worthington's New X compressor is available as a bare compressor or base or tank mounted. Standard belt-driven units are available in ratings from ¾ to 15 hp and 40 to 250 psi. Monobloc units from 1½ to 5 hp, 175 psi. For more information, call Worthington distributor listed under "compressors" in yellow pages or mail coupon.

*Reg. Trademark U. S. Pat. Off.

WORTHINGTON

WORTHINGTON CORPORATION
SECTION 34-3
HOLYOKE, MASS.

I'm interested. Send me a copy of Bulletin 3405-B2 describing your new X compressor line.

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COMPANY_____

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CITY AND STATE_____

POINTS OF VIEW

THE QUESTION: *What Engineering*

John K Northrop
Founder and former president
Northrop Aircraft Corp

Billions of dollars are poured into military aircraft—an industry in which engineers by the thousands work on a single project. How do you develop enthusiasm for and interest in such huge projects? How do you find the leaders? PRODUCT ENGINEERING's West Coast editor took these questions to one of the old-timers in the defense business—Jack Northrop. Here's what the founder of Northrop Aircraft Inc had to say.

Frankly, I feel that the biggest problem facing the defense industries today is breaking through the red tape. I don't think the present system would ever work if there were an emergency. Authority and responsibility should be placed in the hands of a few who are competent, who understand the problem and who can and will make prompt decisions. These are not problems caused by equipment complexity; it's "people complexity." This is Parkinson's Law in action.

At the time we built the Black Widow fighter plane, early in World War II, there were only three individuals directly involved in the contract negotiations. One was an Air Force officer who was a project engineer at Wright Field, one was an Air Force civilian employe, and I was the third. When the Germans were night-bombing Britain, the Air Force needed a radar-equipped night fighter in a hurry to detect and destroy the raiders. In those days, it was still possible to have a meeting of minds and to make decisions quickly. The decisions were prompt, and made by individuals with both the technical ability and authority to do the job.

The Air Force officer and I agreed on the basic design. Then we called in the civilian contract specialist to write the contract. Of course, we didn't do all the thinking on the project—Wright Field's man had all the backing of its facilities; and when he needed a technical decision, he knew whom to call for the best possible answer. And I had a small but competent and enthusiastic engineering backing. But the major decisions that implemented that project were made by only three of us in face-to-face meetings.

To illustrate how rapidly we have gone to the other extreme: In 1952, I was invited to Montgomery, Ala., to address a school for Air Force officers on the relationship between industry and the armed forces. I checked the number of people with whom, for all practical purpose, we had to communicate in negotiating a contract at that time. There were then 432. Now, in 1960, the number probably would be closer to 4000.

Speed and effectiveness are not directly related to the size of engineering groups. However, engineers work best in small, dedicated, enthusiastic units. Often, very little speed is gained by increasing size. I think it's been well proved that you can't do a job faster just by putting more people on it. When dedication and enthusiasm are lost, a vital project often becomes just a job. And "just a job" is man's greatest invention for killing time.

Most of the planes that flew in World War II were designed by small groups. Complex organizations have since developed both in government and industry, each with a tremendous number of echelons that have made it nearly impossible to reach prompt intelligent decisions. By the time your story gets to the man who makes decisions—if he can ever be found—it's lost. You've probably played the game where a group of people form a circle and whisper a message around the ring. That's what it's like—the ending story has little resemblance to its beginning. Too many people have added their personal slant.

You need direct, competent, technical contact, so you can get an answer right away if efficiency and speed are to be achieved. Instead, there are usually so many fingers in the pie that you can't tell who's making decisions. When you have too many people, you can't get a decision at all. Then projects bog down. One or two have to have the responsibility if there's to be progress.

Communication with all employes, not just top-level engineers, is very important. If we had any new and important development—good or bad—I would tell our employes about it in person. Hearing such news directly "from the horse's mouth" has a value in human relations that you can't get any other way. It worked fine; and it was fun.

Unfortunately, as the groups you talk to get bigger you don't have a chance for any questions or discussions, but you still can get a feeling of how people are reacting. If

Problems Face Defense Industries Today?

there were any general questions, I would hear about them before long, and try to answer. And, of course, my door was never closed. I never refused to see a person who wanted to see me. People appreciated this, and they didn't bother me unless they really thought it was important. I tried to be seen in the shop as often as possible, but I always felt that the best I could do was not good enough.

When there were rumblings, or when problems came up, I always tried to meet them head on. New contracts, cancellations–anything that would affect everybody–we always tried to tell the people in the plant directly before they heard the news from another source.

People talk about the problems of finding leaders. Isn't the failure to develop leadership a result of organization buildup? Take a small, enthusiastic group and you find leadership; in a big, regimented, uninspired group, its hard to find. Who wants to be a leader, when every time he tries to accomplish something he runs up against a brick wall–or a feather pillow?

Have you ever seen those traps that ant-lions make? Ant-lions are insects that live on ants they catch by digging a V-shape cone in fine, loose sand. When an ant falls in he tries to crawl up the sides, but can't make any progress because the ant-lion keeps kicking out the sand that the ant pulls down from the walls. Finally, the ant becomes exhausted and gives up struggling.

That's the feeling you get when you have tried to cope with over-organization and gotten nowhere. The desire, incentive and the will to work energetically and happily are gone. Routine does not develop leadership. You can't wait weeks for a minor decision, a year for a letter of intent, and two years for a contract–and still get things done.

Not too long ago, I saw a summary of the 60 most important inventions of the last 10 years. It illustrates many of the points I've been trying to make. Considerably more than half of the 60 ideas were the products of individuals or very small groups working alone. One-fourth were products of individuals or small groups that had been assisted in the later stages of development by larger organizations. The rest–only one-fourth of the total–were the product of big organizations.

In a large company, it is possible to find creative people and put them in small groups where they can get something accomplished. And you have to do a lot of listening to anybody who has an idea to make sure you don't miss the good ones. "Unionmelt," a major breakthrough in the welding industry, was turned down by three companies before Union Carbide Corp brought it on the market.

Some say big organizations are necessary because of the complexity of the things with which they work. But look at the electronics industry where you find lots of new, small companies–young people, small groups–full of ideas, doing exciting things, making a lot of technological progress. If someone were to conduct a poll of the entire engineering profession, and ask "Do you feel you're working effectively?" I'm sure he'd get a large percentage of "No" answers. If you can't use people happily and have them feel that they are being effective, you can't get efficient work. Generally, there's a lack of incentive to do a better job. For the individual, it often means a long and exhausting struggle with red tape in the organization. And there's not much incentive for the company either–at least not for the major defense contractor. If he overruns his budget, the government will usually give him more money to complete the job. If he works efficiently and finishes the job for less than was originally estimated, he is likely to be renegotiated.

When companies grow, you have to pay special attention to communications. No matter if the company is big or small, you have to engender a feeling of belonging –that folks are being treated like human beings and not just as payroll numbers. One of the finest things that ever happened to me was, as a young engineer, to be able to draw a part and then go out into the shop and help build it–to watch it take shape and when changes or modifications were needed, to draw them up and see them put into use. If your connection with the finished product is too remote, you don't have a feeling of contribution. This kills the flash of genius that goes along with a creative job well done, and which is stimulated and nurtured by the feeling of getting something done efficiently and quickly.

But the big need in a creative organization–to generate ideas and keep on generating them–is to maintain a personal relationship and sense of identity with the end product.

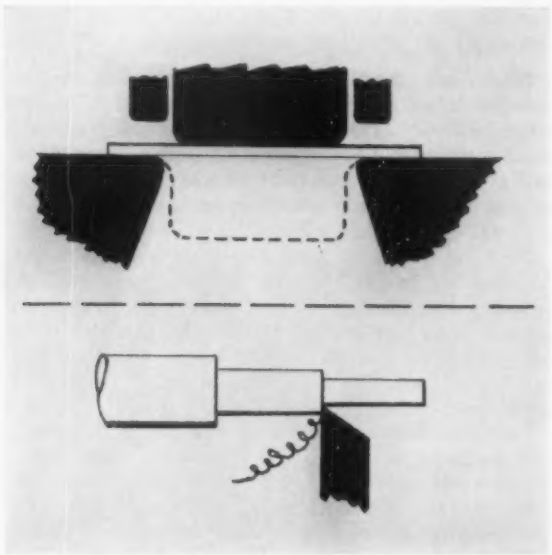
In 1908 a 14-year-old boy named John K. Northrop watched a Frenchman assemble a pusher biplane on a field in Santa Barbara, Calif, fly it around the town and land in front of the Potter Hotel. That experience was enough to launch Northrop's career in aviation. When he reached his 20s, he got a job with Allan and Malcolm Loughead as a mechanical draftsman. In 1923, he went to work for Douglas Aircraft as an engineering draftsman, advancing to designer and finally, project engineer. In 1927, he was one of the four (others, Allan Loughead, Kenneth Jay, Anthony Stadlman) who formed the original Lockheed Aircraft Company. He was the chief, and sometimes the only, engineer.

Two years later he left to research his "flying wing" idea as well as an all-metal plane. These led to his forming Northrop Aircraft Inc in 1939. He remained its president until 1952, when he retired because of ill health.

A few of the significant developments for which he was responsible: The Vega–first high-wing, cantilever monocoque plane; first production development of split flaps; N3PB, world's fastest military seaplane (in 1939); P-61 Black Widow night fighter; B-49 jet-powered "flying wing"; F-89 Scorpion; SM-62 Snark, to name a few.–JM

WHY ARMCO STAINLESS MEET DESIGN NEEDS AT

Armco Stainless Steels enable you to design to your specific needs at least cost because they are available not only in all the standard types but in many special grades as well. You can select an Armco Stainless Steel with the most economical durability; with fabricating properties suited to your design and shop equipment; with special mill finishes, machinability, and heat treatment that cut production costs.



Maximum Economy

Where corrosion problems are not severe, Armco Stainless such as Types 405, 410, 420 and 430 provide necessary durability at minimum cost. Special Armco surface finishes on sheet and strip can eliminate some finishing operations. A wide range of standard and special bar and wire shapes also makes it possible to cut costs by reducing machining operations.

Fabrication Simplified

Armco produces many variations of the standard stainless types to facilitate fabrication and cut production costs. They include 11 free-machining grades, at least one for each basic type of stainless. In addition, Armco Type 304, 304 ELC and 316 ELC simplify production of welded stainless equipment. Grades such as Armco Type 305 plus special Armco processing facilitate drawing and forming.

In designing and manufacturing parts of your products that must be durable, beautiful or strong, you can profit with the specific advantages of Armco Stainless Steels. Write us, describing your requirements, or fill out and mail the coupon. Armco Steel Corporation, 1740 Curtis Street, Middletown, Ohio.

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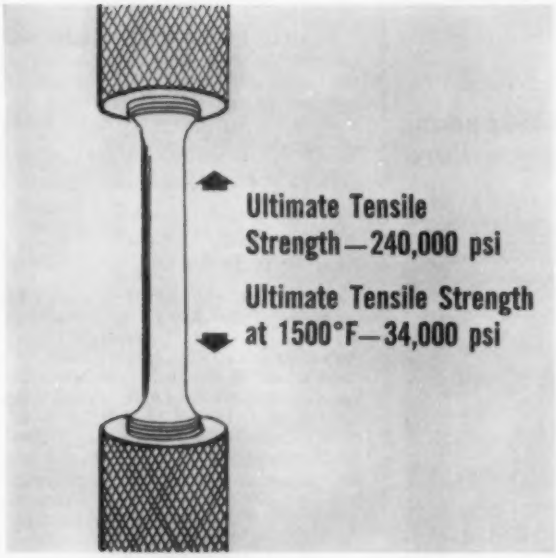

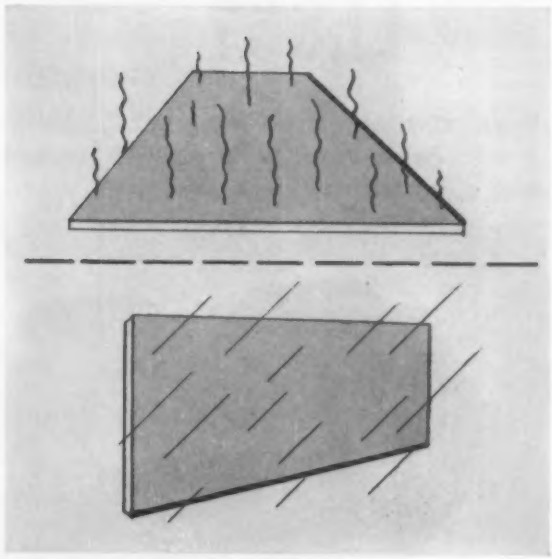

Unique Properties

Armco has developed many special stainless steels with unusual combinations of properties to meet specific demands for better materials. Typical examples are Armco 17-14 Cu Mo with high temperature strength and oxidation resistance; Armco 17-4 PH, 17-7 PH and PH 15-7 Mo with ultra-high strength and hardness plus good corrosion resistance and excellent fabricating properties; and Armco 17-10 P, a high strength grade that is non-magnetic.

Maximum Durability

Where service conditions are severe, Armco's standard or special stainless steels offer the possibility of maximum durability at lowest over-all cost. About 25 different grades of Armco Stainless Steels are available for applications that require superior resistance to oxidation or severely corrosive media in combination with high strength at room and elevated temperatures.

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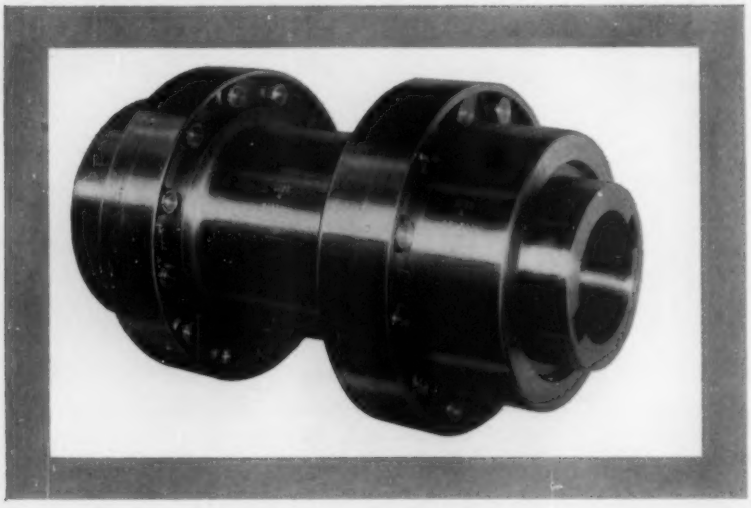
WHAT'S A THOUSANDTH OF AN INCH... MORE OR LESS?

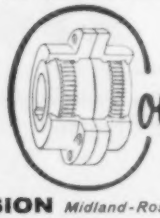
With couplings operating at high peripheral speeds, it can mean the difference between early failure and long trouble-free life.



That's why all Waldron high speed coupling forgings (of SAE 4140) are "rough machined" to +.001", —.000", and then hand finished (sleeves first, then hubs). Bolts and nuts are weigh balanced, and the assembled coupling dynamically balanced as a unit—then match marked for reassembly.

Waldron high speed couplings are now operating at speeds of 70,000 rpm and more, and in drives up to 48,000 HP.

Even if your requirements don't involve such demanding service, it's good to know you have an extra margin of safety and reliability when you specify Waldron High Speed or any Waldron Coupling.

WALDRON  **Couplings**

WALDRON-HARTIG DIVISION *Midland-Ross Corporation*

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READER TO EDITOR

Speaking Can Be Easy

To the Editor:

Your "Steps to Better Oral Reporting" is meaty material. If it has not already come to your attention, ECPD distributes "Speaking Can Be Easy For Engineers" which might be of interest to your readers.

—E C KOERPER, president
Koerper Engineering Associates Inc
Milwaukee

• The 24-page booklet Mr. Koerper refers to, is distributed by the Engineers' Council for Professional Development, 39 W 39th St, NYC—Ed

Local Distributor

To the Editor:

REACTRON, which combines the speed of the shear with the clean cut of the cut-off machine and which you have described in your issue of February 22, p 49 is distributed in the United States and Canada by our organization.

—RENE BOAS
Manufacturers Associates
92 Liberty St.
New York 6

New Benz Looks Old

To the Editor:

Page 16 of your Feb 15 '60 issue shows a picture of "shape of frames to come" for automobiles. This type of frame became known as the traditional Mercedes-Benz frame many years ago. Indeed, take the engine away and the picture could easily be mistaken for a Mercedes of 1935 to 1955 vintage. Several smaller European firms have used somewhat similar layouts.

—W E GAMBLIN
Ottawa, Can.

Nebraska Drafting Group

To the Editor:

I was much interested in Mr Gohrs' reply to Mr Grisvard of Seattle, concerning organizations for draftsmen. (Feb 8, p 28)

Our Nebraska organization is at the Nebraska Vocational Technical School in Milford, Nebraska. We work very closely with industry, vocational schools and colleges. Some 30 to 40 industrial firms are cooperating with us in the development of our program.

—LELAND C TAGGART, *department head*
Drafting Technology
Nebraska Vocational Technical School
Milford, Neb

The Oriental Tortoise and Uncle Sam Hare

To the Editor:

As a footnote to the Electroslag Welding cover (Feb 8), an order for three Vertomatic machines, sight unseen, has been placed by the Arcos distributor in Japan. We are obviously pleased about this. There is, however, an implication completely apart from a sale that compels

a second thought. Three or four large US fabricators have been checking out the quality of electroslag welds prior to placing an order. In the meantime, the Japanese are *buying* three pieces of equipment —as far as we know without demonstration, without sectioning of welds, or extended correspondence on its operation. Whatever the source of their information, their resolution to make use of this new equipment designed for welding heavy equipment can hardly be shrugged off.

Here, again, is another reflection, small, perhaps, but still significant, of our general lack of awareness or almost indifference, to the rate of development in other parts of the world, and the desire to "catch up" with the US. —H E Snyder
Director of Marketing
Arcos Corp, Philadelphia

COMING EVENTS

APRIL

25-29 . . . . American Society of Mechanical Engineers, American Welding Society, Annual Meeting and Welding Exposition, Biltmore Hotel, Los Angeles.

26-27 . . . . Westinghouse Machine Tool Forum, Conrad Hilton Hotel, Pittsburgh.

28-29 . . . . Illinois Institute of Technology, Seminar on Aids in Design Room Management, Urbana, Ill.

MAY

8-11 . . . . National Fluid Power Association, 1960 Spring Meeting, Grand Hotel, Point Clear, Ala.

9-13 . . . . Society of Photographic Scientists and Engineers, 1960 Annual Conference, Miramar Hotel, Los Angeles.

9-13 . . . . American Society for Metals, Southwestern Metal Show, State Fair Park, Dallas.

10-12 . . . . American Institute of Electrical Engineers, Institute of Radio Engineers, Electronic Industries Assn, Western Electronic Manufacturers Assn—Electronic Components Conference, Washington, DC.

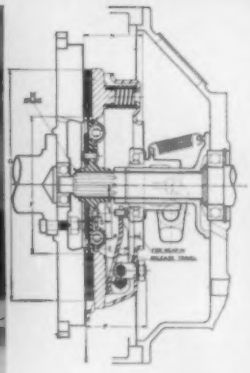
18-20 . . . . Society for Experimental Stress Analysis, Stress Analysis in Propulsion Systems, Indianapolis.

23-26 . . . . American Society of Mechanical Engineers, Design Engineering Conference, New York Coliseum, NYC.

23-26 . . . . Clapp & Poliak, Design Engineering Show, New York Coliseum, NYC.

23-26 . . . . American Institute of Electrical Engineers, Instrument Society of America, American Rocket Society, Institute of Aeronautical Sciences—National Telemetering Conference, Marimar Hotel, Santa Monica, Calif.

ROCKFORD



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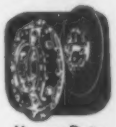
MORE QUALITY
MORE WORK LIFE
In this *NEW 'RT' CLUTCH*

Small Spring Loaded

Automotive Spring Loaded


Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Light Over Center

Power Take-Offs

Speed Reducers

Make more new customers—more profit—by featuring this NEW "RT" ROCKFORD CLUTCH. More performance—it is increased by smooth engagement of precision parts, no binding, grabbing or friction. More quality—it is increased by the patented features of the rolling fulcrum pin, and the precisely balanced throw-out levers. More work life—it is increased by the reduction of friction heat, precision workmanship and the application of advanced research on the clutch facings.

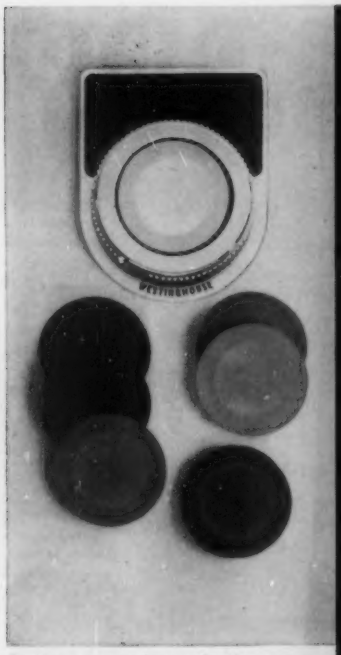
These improved features make the NEW ROCKFORD "RT" CLUTCH a valuable asset to the prime movers of yesterday, today and tomorrow. The NEW "RT" clutch is now being used in high horsepower commercial vehicles and tractors, where rugged stamina is needed. For more new customers and more profits, specify the NEW ROCKFORD "RT" CLUTCH.

SEND FOR THIS HANDY BULLETIN
Shows typical installations of ROCKFORD CLUTCHES and POWER TAKE-OFFS. Contains diagrams of unique applications. Furnishes capacity tables, dimensions and complete specifications.

ROCKFORD Clutch Division BORG-WARNER
209 Catherine St., Rockford, Ill., U.S.A.
Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

ROCKFORD B-W BORG-WARNER

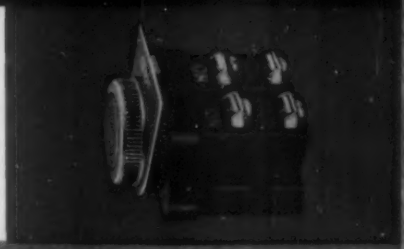
CLUTCHES

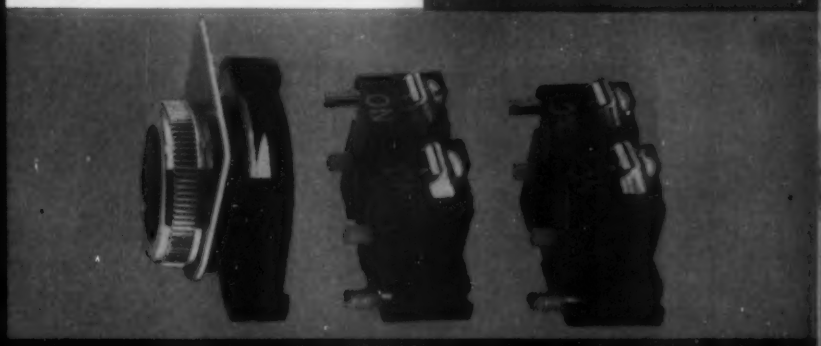


Easily snapped-on plastic caps come in seven colors—red, green, blue, yellow, gray, tan and black—for quick color coding of a push-button bank.

Assembled units (right) permit multiple contacts in limited space. As many as six contact blocks can be coupled to a single pushbutton.

Westinghouse Flush Pushbutton (below) with contact blocks. Notice how one fits directly behind the other. Stacking permits controlling many circuits with one button.





YOU GET... TOTAL DESIGN FLEXIBILITY IN THE WESTINGHOUSE FLUSH PUSHBUTTON

circuit flexibility—unique spacesaving design permits as many as six contact blocks to be stacked one behind the other. You operate all circuits with one push of a button . . . a big help when multiple operations are necessary.

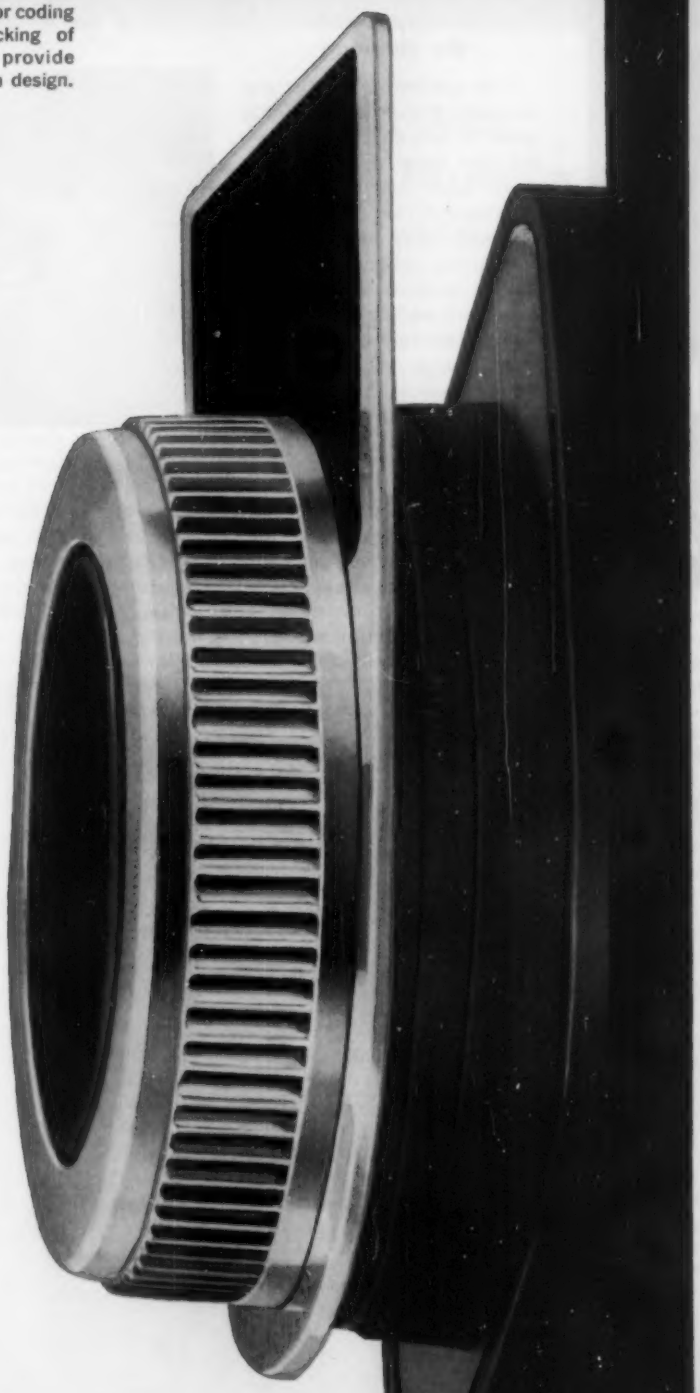
color flexibility—interchangeable chemical-resistant plastic caps come in seven colors: red, green, blue, yellow, tan, gray and black. Choose the best pushbutton for your design and color code it. Permits programming of manual operation using only one model.

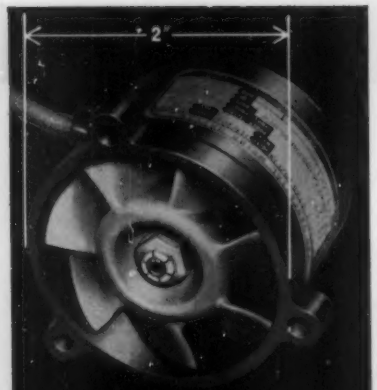
function flexibility—choose from a wide range of operators to suit any use. Standard units available include flush head, mushroom head, extended head, selector switches, push-to-test indicating lights and a host of others.

When your design calls for pushbuttons, you'll find what you need in Westinghouse stock. Call your nearest Westinghouse representative, or write Westinghouse Electric Corporation, Standard Controls Div., Beaver, Pennsylvania. J-30313

YOU CAN BE SURE...IF IT'S Westinghouse

The Westinghouse Flush Pushbutton . . . color coding and multiple stacking of contact blocks provide greater flexibility in design.





HIGH PERFORMANCE 2-Inch Cooling Fan

AiResearch Minifan* is an extremely high performance 400-cycle AC motor-driven fan used for cooling airborne or ground electronic and electrical equipment. Model shown has a flow capacity of 53.5 cfm at a pressure rise of 3.44 H_2O, and requires only 69 watts.

Minifan operates up to 125°C. ambient. Its size and weight make it ideal for spot cooling, cold plates or as a cooling package component. The fan can also be repaired, greatly increasing its service life.

Range of Specifications

- **Volume flow: 21.5 to 53.5 cfm**
- **Pressure rise: .6 to 3.44 H_2O**
- **Speed: 10,500 to 22,500 rpm**
- **Single, two or three phase power**
- **Power: 16 to 69 watts**
- **Standard or high slip motors**
- **Weight: .36 to .48 lb.**

A world leader in the design and manufacture of heat exchangers, fans and controls, AiResearch can assume complete cooling system responsibility. Your inquiries are invited.

***Minifan is an AiResearch trademark.**

THE GARRETT CORPORATION

AiResearch Manufacturing Division

Los Angeles 45, California

FOR YOUR INFORMATION (personal)

Do-it-yourself dry cleaning

Coin-operated dry-cleaning machines may become as big a splash as coin-operated washers, and pave the way for home-size units. Right now, they're still experimental, but at least two companies have prototypes out on test; one, designed by Whirlpool, is pictured here. Another is being made by Standard of Dallas. The units hold about 9 lb of clothes, use regular dry-cleaning solvents.

Coins per load: 4 quarters.

Are you electronic?

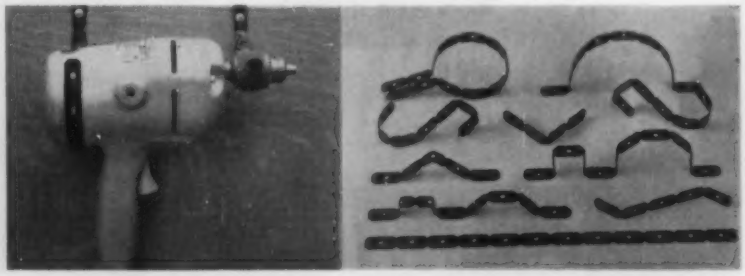
If you design semiconductor devices or any of these—resistors, capacitors, relays, structural electronic components; wire and cable assemblies, dial assemblies; computing and associated information-processing devices (except airborne); scientific, industrial and laboratory instruments; electronic control devices other than electronic missile-guidance control devices (signals, alarms, automatic industrial controls), you are *not* part of the electronic equipment industry. Not by official definition proposed by the Electronic Industries Association.

EIA's definition, proposed to the Labor Dept, and specifically designed for wage determination purposes, limits the classification "electronic equipment industry" to those who make such equipment as radio and TV transmitters and receivers; electronic surveillance and tracking devices; electronic airborne information-processing devices; electronic missile-guidance control devices; electronic sound-distribution devices (including public address and music distribution apparatus, except records); and electronic power supplies for use in any of the foregoing classes of products.

The others are still part of the *electronics* industry—but they're not electronic-*equipment* makers.

Strips come ready for work

Notched, pre-punched strip for applications ranging from shelf brackets to pipe clamps (see photos) is being made by Addy Products Ltd, Millbrook Trading Estate, Southampton, England. Not yet on the US market, it's being introduced in Britain in two types: rustproof mild steel (in red and green) and electrozinc galvanized. Both types are 16-gage (0.064 in.) steel with V-notches at 1-in. intervals. Holes are ⅜ in. dia. British prices are about $4.20 for a package of two dozen 18-in. strips of the rustproofed material, and $8.40 for a package of a dozen galvanized strips in 6-in. lengths. (Individual prices are 17¢ per strip for the rustproofed and 12¢ per foot for the galvanized). —ARG



Quiet...

WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

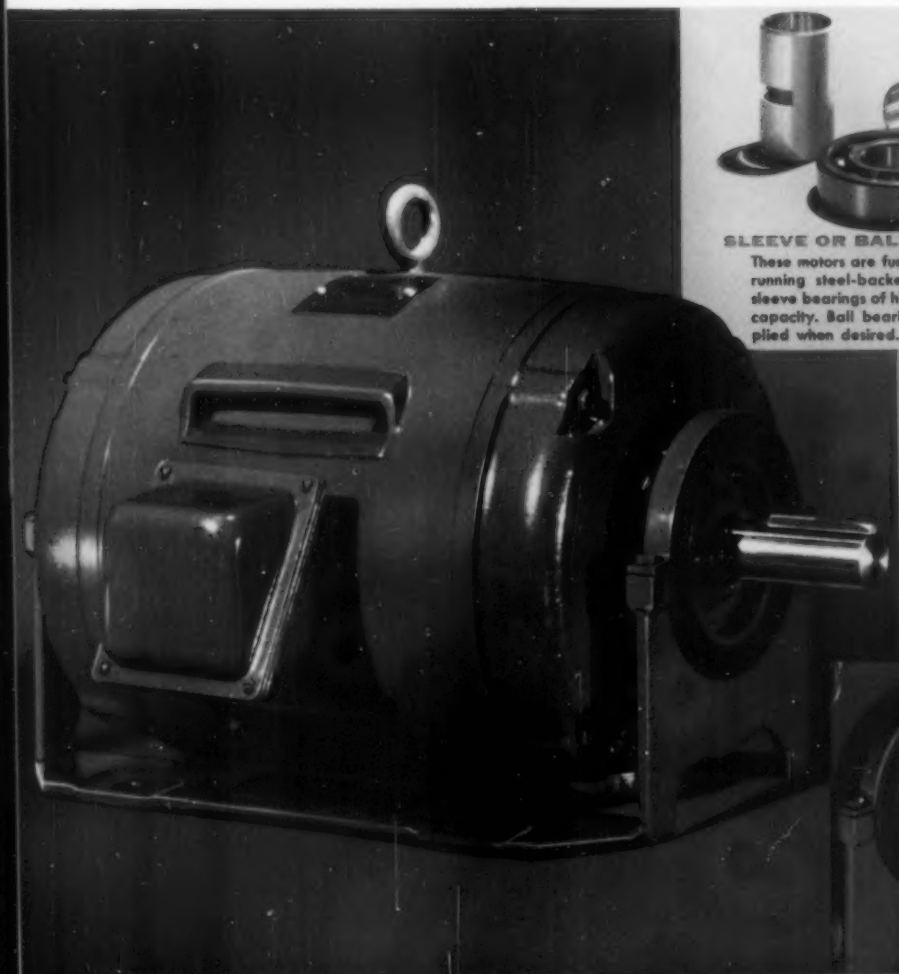
Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

Your nearby Wagner Sales Engineer can help you select the right motor to meet your requirements. There are Wagner branch offices in 32 principal cities.

Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

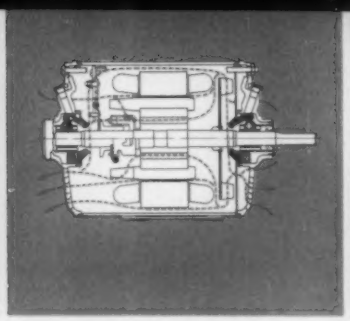


SLEEVE OR BALL BEARING.
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

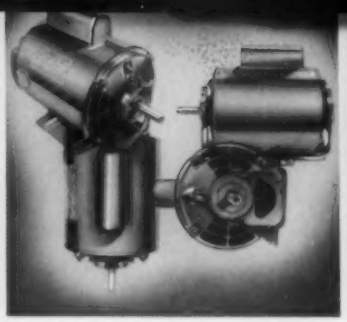
CEILING, SIDEWALL OR HORIZONTAL MOUNTING.
You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

NEOPRENE CUSHIONING RING.
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.

Quick Break Switch. The starting winding is disconnected from the line by this Wagner designed switch . . . test proved to make more than a million breaks. (That adds up to two starts per hour for 50 years!)



Efficient Cooling System. The improved ventilating system used in these motors directs a large volume of air through the motor to effectively reduce temperatures and add to motor life. Cross section indicates direction of air flow.



All-Angle Operation. The sleeve bearing design, in fractional hp ratings, has a positive lubrication system that permits operation in any position . . . can mean important savings in motor costs to manufacturers.

Quick Connect Terminals. Brass tabs on terminal studs permit quick, easy connection of leads . . . cut wiring time to speed assembly line production. Simply press the lead receptacle on to the stud—a positive connection is assured.

NO STARTING PROBLEMS with WAGNER CAPACITOR-START MOTORS

Pack more power into less space...give long troublefree service...are easy to hook up

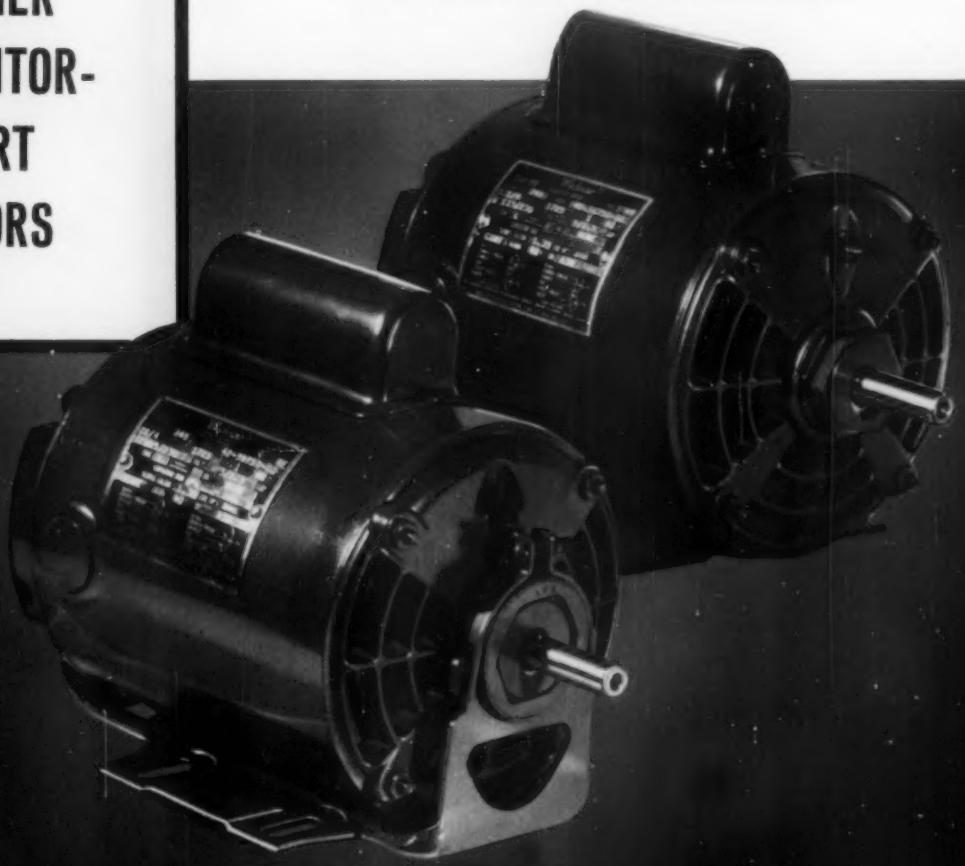
Here are general purpose single-phase motors that have high starting torque and high pull-in torque. When used in the proper application and supplied with voltage close to their rating, they'll give positive starts every time. Troublefree operation is assured . . . thanks to the positive action of the Wagner governor mechanism and long life quick-break switch.

Wagner Type RK Motors pack more power into less space. Small enough to fit in tight spots, their ruggedness is built-in . . . permits direct mounting. And, sleeve bearing fhp models can be operated in any position. They are available in a range from 1/6 through 5 horsepower, with sleeve or ball bearings, and with rigid bases or resilient mountings.

Get these motors from leading motor distributors in your city, or from Wagner sales offices in 32 cities across the country. Your Wagner Sales Engineer will be glad to help you select the right motor for your application. Wagner Bulletin MU-217 gives full details on Capacitor-Start Motors.

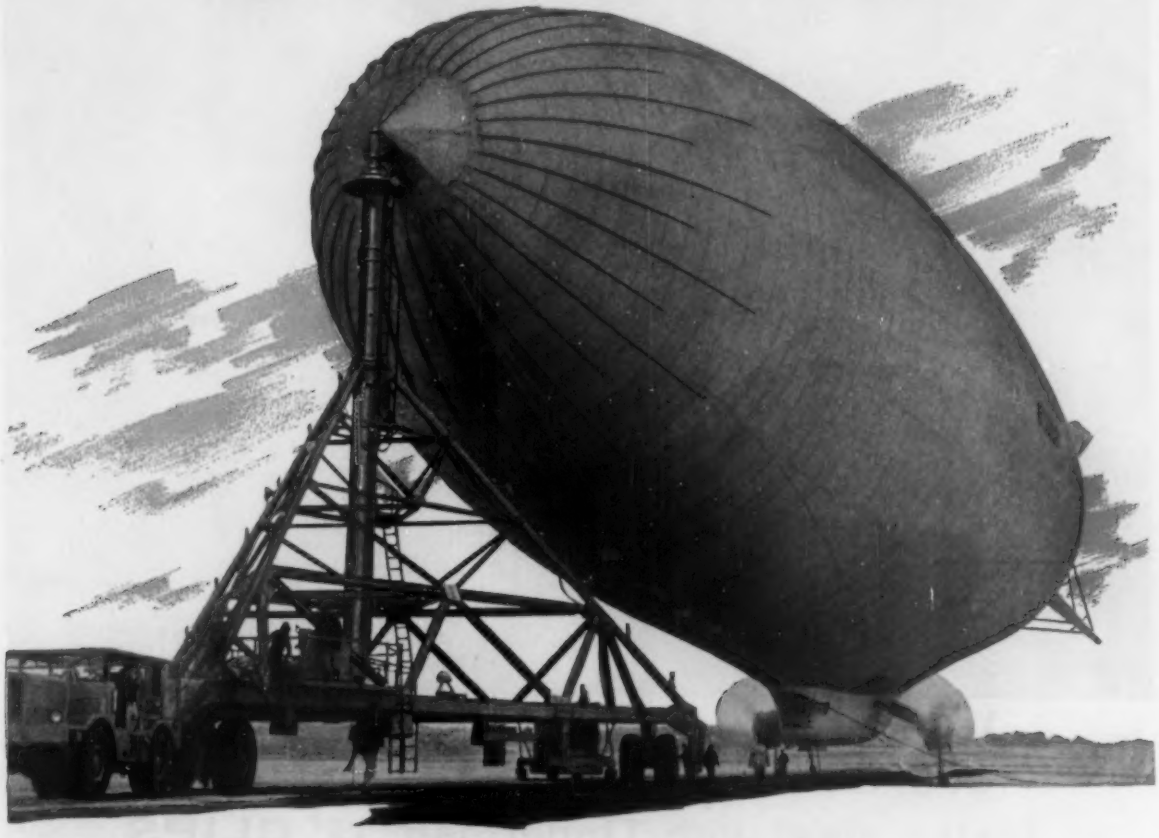
Wagner Electric Corporation
6400 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WM60-I



"Hitching Post" for Navy Blimp!

uses a 19-foot Saginaw b/b Screw!

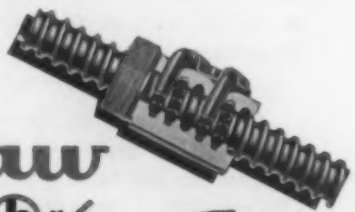


A Saginaw Ball Bearing Screw is located in the vertical column of these telescoping Goodyear Blimp Mooring Masts! The screw's extremely low friction and rapid positioning ability synchronizes the mooring fixture with the nose of the blimp to quickly and safely secure the Navy craft.

The huge high-efficiency Saginaw b/b Screw used here is over 19 feet long and with a B.C.D. of 6 inches. From the tiniest Saginaw Screw used in instrumentation, to this giant used in the Goodyear Mooring Mast, the principle of the Saginaw Ball Bearing Screw is almost universally adaptable. Its ability to replace acme screws and hydraulic devices *with over 90% efficiency* has already assured smoother, more dependable actuation for over 5,000 satisfied customers!

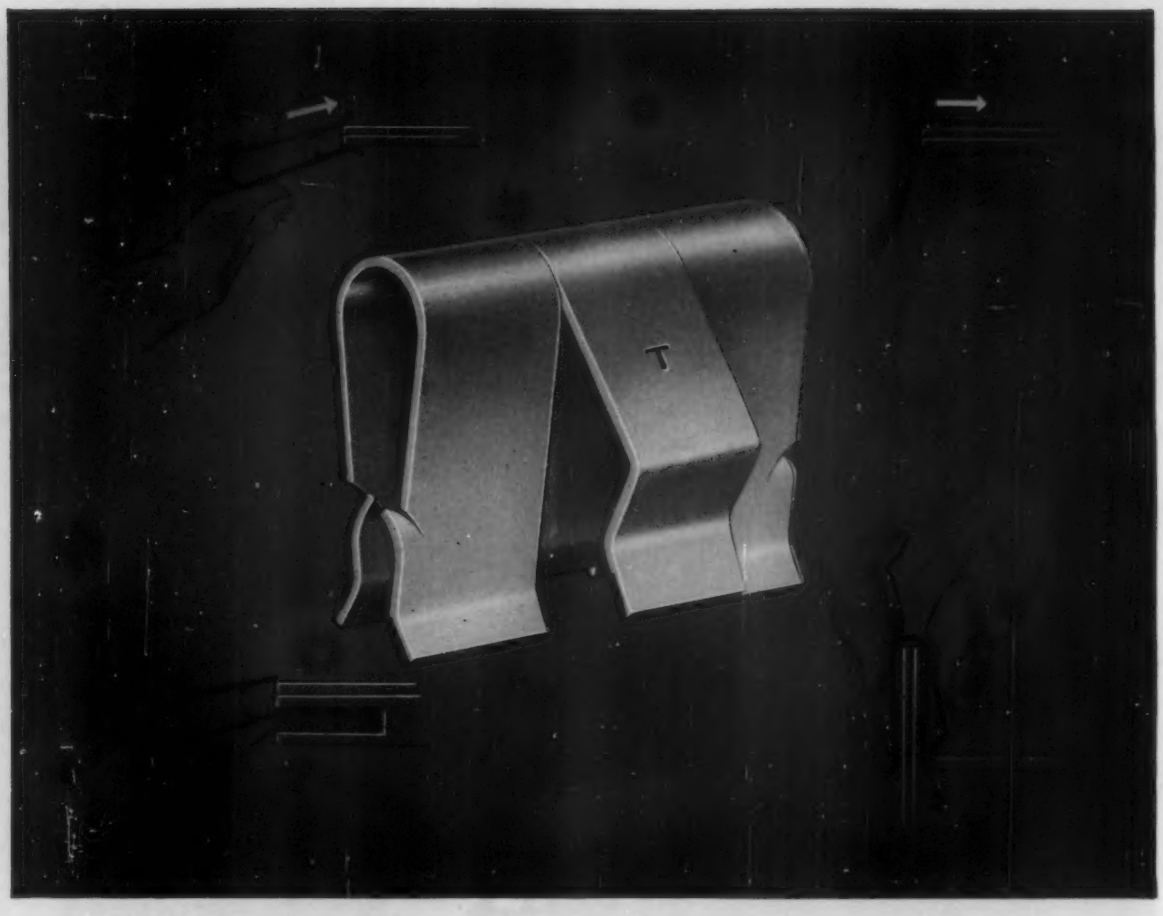
The Saginaw Screw may be able to improve *your* product's performance, give you greater power and maintenance savings, and lower your initial cost. Talk your actuation problem over with Saginaw's engineers. Just write or phone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan—*world's largest producers of b/b screws and splines.*

Actuation To Fit Your Individual Requirements
Have been built as small as 3/16 in. B.C.D. and 3/4 in. long, as large as 6 in. B.C.D. and 40 ft. long. Larger sizes can be built to your order.



Saginaw b/b Screw

WORLD'S MOST EFFICIENT ACTUATION DEVICE



Another SPEED NUT brand fastener...

Just a thumb-push...and steel teeth fasten steel with Tinnerman "U" CLIPS

Twin-action gives this Tinnerman "U" SPEED CLIP® extra holding power in fastening together two sheets of metal, plastic or wood without screws... the heat-treated spring steel tension in the "U" exerts a clamping action... the tiny upset barbs bite in and hold on for keeps.

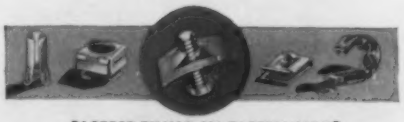
Cost of assembly is substantially reduced when you use Tinnerman "U" Clips for fastening... extra assembly steps are eliminated... no special tools or skills are required... and Tinnerman "U" Clips hold for good!

SPEED NUT Brand "U" Clips are easy to apply ...merely thumb-push them over the edges of the panels. A variety of Tinnerman fastener features can also be incorporated with the "U" Clip principle...cable clips, protruding legs to hold glass panels in lighting fixtures, and others.

Call your Tinnerman SPEED NUT representative today... if he's not listed in your "Yellow Pages" Directory under "Fasteners", write direct.

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®



FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Treforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

PRODUCT ENGINEERING HORIZONS

April 25, 1960

WHO'S PULLING THE STRINGS?

Puppetry is both a science and an art in the USSR. I've never seen better than the Teatr Kukl in Moscow. The night I was there they played a sardonic farce called "The Rustling of Her Eyelashes." Even though the language wasn't American, the subject was our movie industry, and the acting was barbed satire. The dialogue is too, I've been told.

I relate this incident only because it may have much broader implications. Is our defense effort being similarly manipulated from almost half a world away? Are we being drawn into diverting our scientists and engineers to the wrong jobs? We've applied a high percentage of our electronic and mechanical talent to development of defense against catastrophic attack, like the DEW and SAGE lines, the Nike and similar defense missiles. Many voices are crying for us to dig private hideaways in our backyards. Even our attack program envisions long-range missiles that can't be wiped out in one fell swoop by one particular enemy.

Yet every volume of history cries out against a program bulwarked by defense bastions. It has never worked. Troy, Rome, Samarkand had unbreachable walls—and every one was captured by trickery that bypassed walls. France built the Maginot Line, and the Germans hit the hinge. Germany built the Siegfried Line and the Atlantic Wall; we smashed both.

The advantage has always been with the attacker, particularly the unconventional one. Anyone can duplicate such "victories" as the Little Big Horn and the Alamo, given enough men. But the big battles, and the wars, have been won by attack coupled with trickery and surprise.

We worried about bombing or shelling in World War II when the real danger was sabotage. We expected a cloak-and-dagger saboteur; the real danger was from men trained to look, act and live just like us. Explosives are too easily detected, but who will notice a lighted cigarette lying across an open matchbook near flammable materials? And who would suspect a ship with a hydrogen bomb in her vitals, particularly if it were marked as luggage—or balalaikas? The modern bomb can be sent by air express. Are we remembering these possibilities even now?

We are engaged in a race to put a man into space, to the engineering exclusion of a great many other things. What of non-space transportation? What of education? The relationship between modern technology and sociology and between "science" and government? What of our inflationary cost spiral? There seems to be much less energy expended toward solutions in this direction. Yet these problems are the ones that will shape our future national course.

Increasingly, we hear the missile men and the space men and the arms men generally say that the program is shaped by the latest from Moscow.

Who's pulling the strings?

R. J. Langeman

"ALCOA ALUMINUM OFFERS A CHOICE OF TWO SCREW MACHINE STOCK ALLOYS FOR STRENGTH: 2017 AND 2024!"

Precision-made, high-volume screw machine parts cost less in aluminum

Here are the strongest of all Alcoa® Aluminum screw machine alloys. Both will give you superb machinability. Both will give a fine, clean finish. Alcoa Alloy 2017-T4 or -T451 is exceptionally good for deep drilling operations. Alloy 2024-T4 or -T351 offers high shear strength . . . which makes it a popular choice for fasteners and fittings. These alloys will give three times as many parts per pound as other, heavier metals, raise your profits by cutting your over-all unit costs.

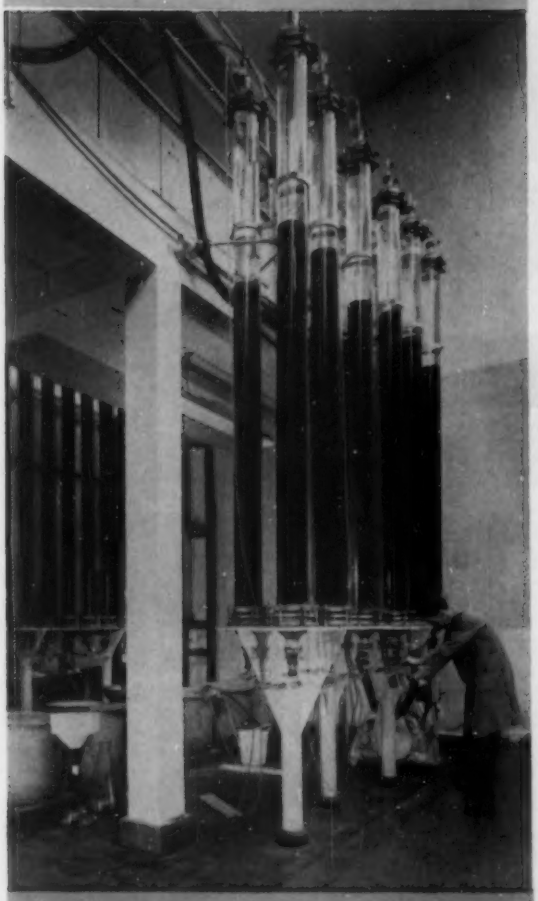
Ask your Alcoa distributor or Alcoa sales office for your free *Alcoa Conversion Calculator* . . . which makes cost conversions from brass to aluminum and computes costs quickly . . . and your free *Alcoa Screw Machine Stock Estimating and Operating Data Book,* a comprehensive, easy-to-use book of technical data on aluminum screw machine stock. Get full information on other Alcoa alloys: 2011-T3 or -T8 for faster cutting, 6061-T6 or -T651 for superior finishes, excellent joining characteristics and extra corrosion resistance. Aluminum Company of America, 841-D Alcoa Building, Pittsburgh 19, Pennsylvania.

GET ALL THESE BONUSES WITH EVERY ALCOA ALLOY:

1. Wide range of stock sizes for important price advantages.
2. Guaranteed market for up to 60 per cent of your Alcoa Aluminum turnings and borings.
3. Extensive mill and distributor inventory to meet all requirements.
4. Chamfered ends at no extra cost.
5. Specific 12-ft lengths at no extra cost (for rounds up to 2¾ in.; hexagons up to 2 in.).

ALCOA ALUMINUM

SCREW MACHINE STOCK



SEPARATION OF RARE EARTHS calls for forests of ion-exchange columns like these; explains current high cost of the high-purity rare earths. As new commercial units are built, supplies will increase and costs will drop. This experimental plant is at Johnson Mathey in England.

In most textbooks, the rare earths are given short shrift as the "minor metals." In the chemist's periodic table, they fall in the III-B group, forming a little series of their own. But in industrial and government laboratories today, they're receiving top priority. Here's why—and what they mean to you.

not rare,
not overabundant,
but
increasingly useful . . .

THE RARE-EARTH METALS

ANNESTA R GARDNER, *associate editor*

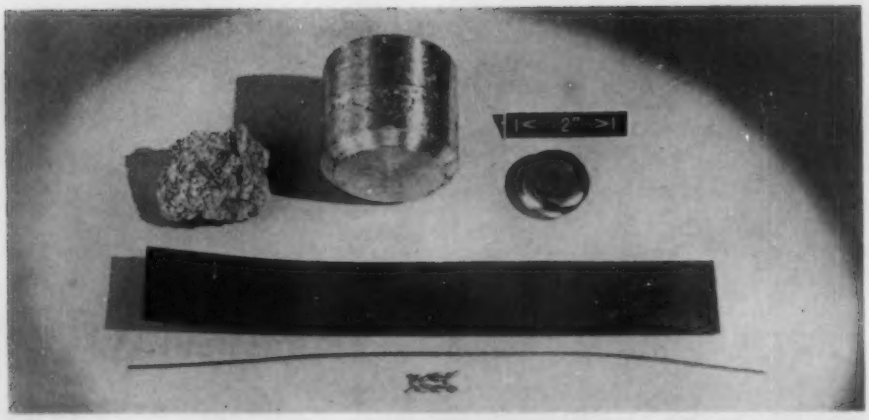
Compared with many of the elements now receiving serious attention as structural materials, the rare-earth metals aren't rare at all. Even the scarcest of them is estimated to be four or five times as common as silver.

Furthermore, at least one of the group, cerium, is found in almost every household and factory. It's used in cigaret-lighter flints and as a scavenger for steel.

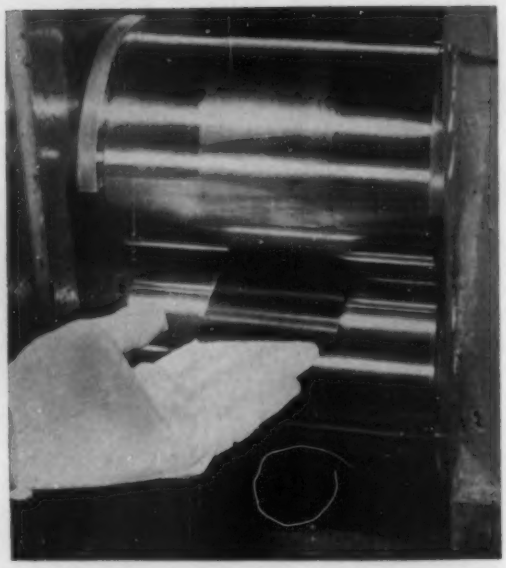
But until very recently, none of these 17 metals was available in the high-purity form essential for developing structural, electrical and nuclear uses. Now, there are at least half a dozen suppliers of high-purity metal—and several potential suppliers closely eyeing the field.

Why the Sudden Interest?

The high-purity rare earths show great promise for improving the properties of both ferrous and nonferrous metals. They have valuable electrical properties, and they contribute special qualities to glass and ceramics. Even in



HIGH-PURITY METALS—yttrium sponge, ingot, button, strip, and wire—produced at Bureau of Mines plant, Albany, Ore.



GADOLINIUM sheet and bimetal strip are being produced experimentally by Metals and Controls Div, Texas Instruments.

Rare-earth Glossary

RARE EARTHS. The metals numbered 57 through 71 in the periodic table of elements. To this group, two others, yttrium (39) and scandium (21), are often added.

LANTHANIDES. The rare earths—so named because lanthanum is first of the group.

MISCH METAL. A mixture of rare-earth elements—mostly in the light group, with cerium predominating. It's obtained as a byproduct of processing thorium-containing monazite sands.

DIDYMIUM: Like misch metal, a mixture of rare earths, largely praesodymium and neodymium with little or no cerium.

LIGHT RARE EARTHS. The lower numbered elements of the lanthanide group (numbers 57 through 63). Scandium and yttrium, though even lighter in atomic weight, are much more similar in physical and mechanical properties to the higher numbered group.

HEAVY RARE EARTHS. Orginally, this term meant the higher numbered rare earths (numbers 64 through 71). It is increasingly used, though, to describe the heavy actinide elements numbered 89 through 103, which are, in many ways, similar to the original rare earths.

ACTINIDES. The heavy metals occupying places 89 through 103 in the periodic table. They take their name from the first of the group, actinium (89), and include several man-made elements.

impure form—as *misch metal* (see glossary)—rare earths markedly improve the high-temperature properties of aluminum and magnesium; increase the hardness of copper and the oxidation resistance of high-nickel alloys.

One of the metals, yttrium in small percentages, markedly increases the oxidation resistance of iron-chromium alloys. Adding about 1% of yttrium to 25% chrome stainless, for instance, can give it the degree of oxidation resistance at 2500 F that it normally has at 2000 F. In pure chromium, yttrium is even more effective, adding unusual stability and oxidation resistance at elevated temperatures.

In elevated-temperature properties, alloys of magnesium with the rare earths are considerably superior to conventional alloys (Mg-Al-Zn). But none, so far, seem to approach the new Mg-thorium compositions. However,

most rare-earth work to date has been done with misch metal and other rare-earth mixtures rather than with the pure elements, and preliminary work with high-purity metals indicates much better results can be achieved. Test heats of Mg-yttrium alloys show considerable promise, and there is at least an indication that heat-treatable alloys may be found in this system.

Their Compounds Serve Too

Applications already found for rare-earth chemicals point the way to uses in other fields:

- Cerium oxide and rare-earth oxide mixtures serve as glass-polishing compounds.
- Rare-earth mixtures in searchlight electrodes increase light intensity.
- In electron tubes, rare earths serve as "getters" to remove gases, as activators for electroluminescent phosphors, and as thermionic emitters.
- Rare-earth oxides also contribute special properties to glass and ceramics. Cerium oxide in atomic-radiation-absorbing glass helps prevent darkening under irradiation. It can serve as an opacifier for porcelain enamels, producing glazes with high light reflection, high gloss, and good acid resistance.
- The cerium-free rare-earth mixture didymium gives welding glass its ability to absorb yellow light.

Because many of the rare-earth oxides have attractively high melting points (oxides of Y, La, Nd, Sm, and Gd all melt above 4000 F), they are under test for high-temperature resistors, phosphor coatings, semiconductors, and magnetic components. One such material, the yttrium-iron "garnet," is already proving its value in microwave applications (*PE*—Oct 20 '58, p 11); and rare-earth semiconductors are under development, with selenides and tellurides of La, Er, Y and Gd showing particular promise. Cerium sulfide, too, is a high-temperature compound that shows promise for refractory applications.

Magnetic Properties

The magnetic and electrical properties of the rare earths open up a good many other interesting possibilities.

As a group, these metals cover the range of magnetic attributes—ferromagnetic, antiferromagnetic, and paramagnetic. Several of the elements exhibit all three types of behavior. Holmium for instance, is ferromagnetic below −424 F; antiferromagnetic from −424 F to −223 F; paramagnetic above that. Furthermore, the metals can be alloyed to broaden the range still more.

Alloying gadolinium with lanthanum and yttrium makes it possible to secure a complete spectrum of ferromagnetic and antimagnetic behaviors; and at least two lanthanum alloys (with yttrium and lutetium) show definite evidence of superconductivity.

Unusual magnetic properties promise to make several of them useful in attaining extremely low temperatures by adiabatic demagnetization (*PE*—Aug 4 '58, p 24).

The Hall effect has been measured for ytterbium, lutetium, thulium, samarium and several others—and here again, a wide range of characteristics is available. Ytterbium has a positive Hall coefficient; lutetium and thulium are negative; samarium is negative at room temperature but seems to become positive as temperature goes down. These four seem well worth investigation for thermoelectric conversion devices and Hall-effect transducers (*PE*—May 4 '59, p 32).

Physical Properties

Because the rare earths are still "new" in high-purity form, there are still gaps—often big ones—in their tables of physical and mechanical properties. But the basic facts are known. The rare earths as a group are relatively soft metals that look much like iron. Their thermal expansion compares with that of glass and many of them have high melting and boiling points. In other respects, though, they exhibit a wide range of properties.

In general, mechanical strength, hardness, and corrosion resistance follow the listing in the periodic table (see p 43), with those having the lowest numbers showing the lowest strength (12,000 to 20,000 psi) and least corrosion resistance.

Scandium and yttrium, the two outlying elements in the group, are exceptions. They have the lowest atomic numbers but fall with the higher numbered group in physical properties. The members of this group (Sc, Y, and elements 64 to 71, except Yb) have tensile strengths from 25,000 to 42,000, which can be increased 50 to 75% by cold working. Sc and Y have particularly good strength/weight ratios; and, even at 800 F, they retain at least 40% of their strength.

In moist air or salt spray, all the rare earths corrode rapidly. In dry air, Sc and Y resist oxidation at least to 200 F, and samarium to 1000 F. High-purity neodymium retains its metallic luster for some time. But europium oxidizes rapidly even at room temperature.

The metals are quite easy to machine; but the fact that many of them do burn readily calls for special precautions to prevent overheating.

Thermal conductivities range from 0.021 (for Gd) to 0.035 (for Y) cal/cm²/cm/sec/°C at 28 C.

Specific resistance at 32 F ranges from 30×10^6 ohm/cm³ (for Yb) to about 140×10^6 (for Gd).

Nuclear Properties

The nuclear properties of the rare earths show a wide and extremely useful range. The thermal neutron cross-section of cerium (tendency to take up neutrons and thus interfere with nuclear reactions) is only 0.7. This is just slightly above that of magnesium, aluminum and zirconium, all widely used as structural materials in nuclear reactors. On the other hand, the value for Gd is 20 times that of cadmium and nearly 70 times that of boron, the most widely used control-rod elements.

The nuclear properties of the rare earths have done

Symbol	Name	Atomic No.	Abundance (Cu=100)	Density, gm/cc	Brinnel Hardness	Melting Point, °F	Boiling Point, °F	Electrical Resistivity at 55 F, ohm-cm x 10^6	Thermal Conductivity at 55 F, btu/hr/°F/ft²/in.	Thermal Neutron X-section	Ultimate Tensile Strength, psi	Yield Strength (as cast), psi	Price $/gm (50- to 100-gm lots)
Sc	SCANDIUM	21	13	3.0	75	2850	5900	23		22	45,000		50.00
Y	YTTRIUM	39	4.3	4.5	60	2870	5450	80	10.1	1.38	45,000	20,000	0.60
La	LANTHANUM	57	0.2	6.2	37	1690	7800	62	9.6	8.9	19,000	18,000	0.34
Ce	CERIUM	58	0.3	6.8	28	1480	6500	75.0	7.5	0.70	17,000	13,000	0.50
Pr	PRAESODYMIUM	59	0.1	6.8	37	1720	6240	70.0	8.1	11.2	16,000	15,000	0.60
Nd	NEODYMIUM	60	0.5	7.0	35	1880	5970	64.3	9.0	46	25,000	24,000	0.60
Sm	SAMARIUM	62	0.1	7.5	45	1930	3450	88		5500	18,000	16,000	0.60
Eu	EUROPIUM	63	0.05	5.2	17	1570	3000	81.3		4600	12,000		8.00
Gd	GADOLINIUM	64	0.3	7.9	57	2400	5430	135	6.1	46,000	45,000	26,000	1.00
Tb	TERBIUM	65	0.05	8.2	60	2600	5100			44	25,000		6.00
Dy	DYSPROSIUM	66	0.3	8.6	50	2700	4710	56	7.0	1100	37,000	33,000	1.10
Ho	HOLMIUM	67	0.1	8.8	45	2730	4900	87		64	35,000	32,000	1.10
Er	ERBIUM	68	0.3	9.1	50	2800	4720	107	6.7	166	42,000	42,000	1.10
Tm	THULIUM	69	0.1	9.3	48	2820	4300	79		118			5.50
Yb	YTTERBIUM	70	0.2	7.0	21	1520	3270	30		36	10,000	9,000	1.50
Lu	LUTETIUM	71	0.2	9.8	77	3100	6300	79		108			13.00

Properties of the Rare Earths

These metals are still so new, and preparation and fabrication techniques vary so widely that the figures here can only be considered approximations or averages. They do, however, indicate the general range available. Abundance figures are based on Cameron's data (PE—Nov 2 '59, p 13), converted to copper as the base; other data are from sources listed on p 43. It should be noted that abundance figures, as such, may not indicate current commercial availability; and prices will vary considerably, depending on degree of purity and quantity ordered. Cerium and lanthanum, for instance, are available from at least one source in pound lots at less than $40/16; and one company also offers a specially priced tryout kit. (Note—only 16 metals are shown in the table because promethium, No. 61, does not occur in nature.)

much to spur interest in them and in the separation techniques that could make high-purity metal available at reasonable cost. Separating these metals isn't easy. Although they differ a good deal physically and electrically, they are very similar in chemical properties.

This is why, even now, the metals are still very costly. The cheapest of them, in pure form, is about $40/lb (misch metal, though, is only about $3.50). But, as demand grows, prices for the rare-earth metals may well drop into the range of $5 to $20 a lb.

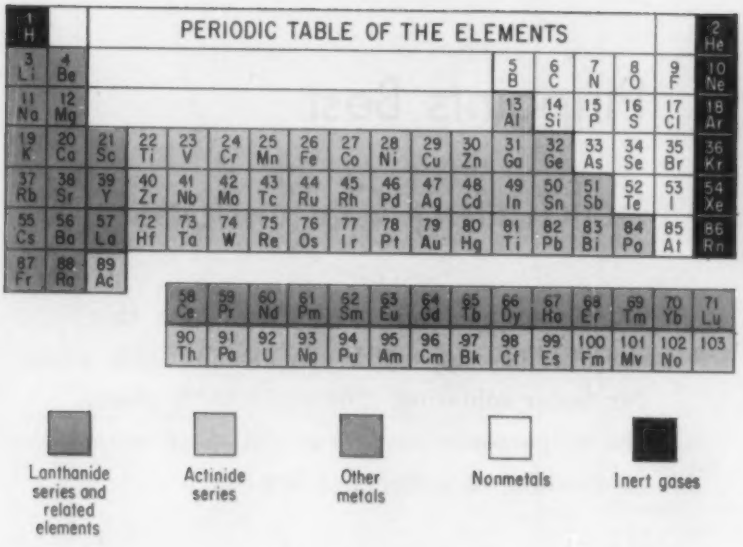
How They're Related

The association of the rare earths with thorium is not accidental. The rare earths proper are a single group in the periodic table, just as are the actinide elements that include uranium, thorium, and plutonium. The resemblance is so close, as a matter of fact, that the heavy elements are often labeled the "heavy rare earths"; and it has been possible to predict many of the properties of the man-made elements beyond uranium on the basis of their position in relation to the members of the rare-earth series.

Yttrium (No. 39) and scandium (No. 21), do not fall in the main rare-earth series. But, as the periodic table shows, they do fall in line directly above the rare-earth groups and have similar chemical properties.

What's Ahead

Much remains to be learned about the rare earths and what they can do, so it's dangerous to generalize too much. For instance, evidence so far indicates that the various rare earths have decidedly different effects when used as an alloying element, and certainly differ widely in magnetic and electrical properties. But it is these differences that hold the greatest promise for applications of these metals in the future. ■



PERIODIC TABLE shows relationships among the rare earths. Sc, Y, La and Ac are arranged vertically in group III-B. Nos. 58-71, here shown as a horizontal group, stem from No. 57, as 90-102 stem from No. 89. Note, too, the position of Sc between Ca and Ti, both of which it resembles; and the proximity of Y and Zr.

WHERE TO GET INFORMATION ON RARE-EARTH METALS

PUBLICATIONS

Publications of Ames Laboratory (on rare earths), PO Box 14 A, Ames, Iowa

AEC, USAF, and other publications on rare earths and unusual metals:
OTS, Dept of Commerce, Washington 25 DC

Unclassified Atomic Energy Literature (TID 4500) Tech Info Service Extension, USAEC, PO Box 62, Oak Ridge, Tenn

SUPPLIERS

Producers of high-purity rare-earth metals

City Chemical Corp, 132 W 22nd St, New York 11

Lindsay Chemical Div, American Potash & Chemical Corp, 99 Park Ave, New York 16

Lunex Co, PO Box 196, Pleasant Valley, Iowa

Michigan Chemical Corp, Rare Earths and Thorium Div, St Louis, Mich

Research Chemicals Div, Nuclear Corp of America, PO Box 431, Burbank, Calif

Ronson Metals Corp, 45–65 Manufacturers Place, Newark 5, NJ

St Eloi Corp, Box 507, Newtown Station, Cincinnati 44 (scandium)

Union Carbide Metals Co, 30 East 42nd St, New York 17 (scandium)

Producers of special forms

Bridgeport Brass, 30 Grand St, Bridgeport 2, Conn (fabricator)

Texas Instruments, Metals & Controls Div, 34 Forest St, Attleboro, Mass (fabrication and cladding)

Sintercast Div, Chromalloy Corp, 134 Woodworth Ave, Yonkers, NY (powder-metallurgy products incorporating rare-earth dispersions)

Vitro Chemical Co, 342 Madison Ave, New York 17 (limited supplies of some metals)

OTHER INFORMATION SOURCES

Battelle Memorial Institute, 505 King Ave, Columbus 1, Ohio

Bureau of Mines, Albany Metallurgy Research Center, PO Box 492, Albany, Ore

General Electric Co, Aircraft Nuclear Propulsion Dept, Cincinnati 15

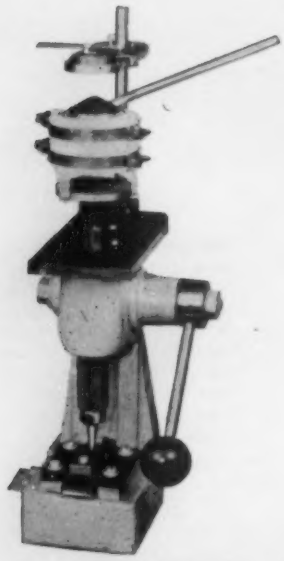
REPRINT COPIES of this report are available for 25 cents each by addressing Reader Service Dept., Product Engineering, 330 W 42nd St, New York 36, NY.

EDITORS NOTE: For more on rare and unusual metals, see these past articles:

Exotic Metals Seek Employment, Mar 17 '58, p 66; a roundup of properties and uses of these metals—gallium, chromium, vanadium, hafnium, bismuth, beryllium, and indium.

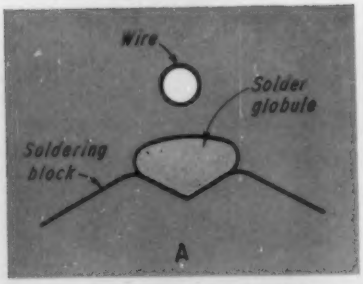
Heavy Metal Solves Weighty Problems, July 21 '58, p 62; high-tungsten alloys for counterweights and rotating elements, X-ray shielding, and nuclear applications. Has chart of physical properties.

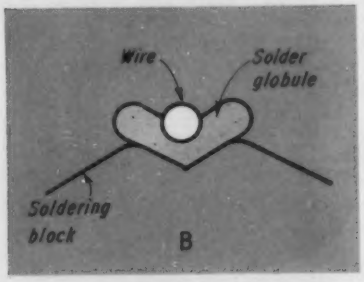
Taming Tomorrow's Power Sources, May 4 '59, p 32; background on semiconductors and energy-conversion systems using Seebeck, Hall and Peltier effects.

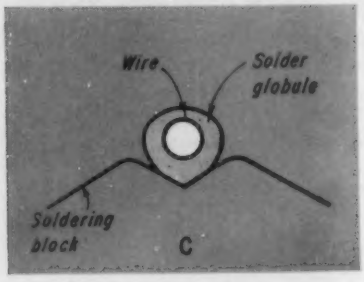


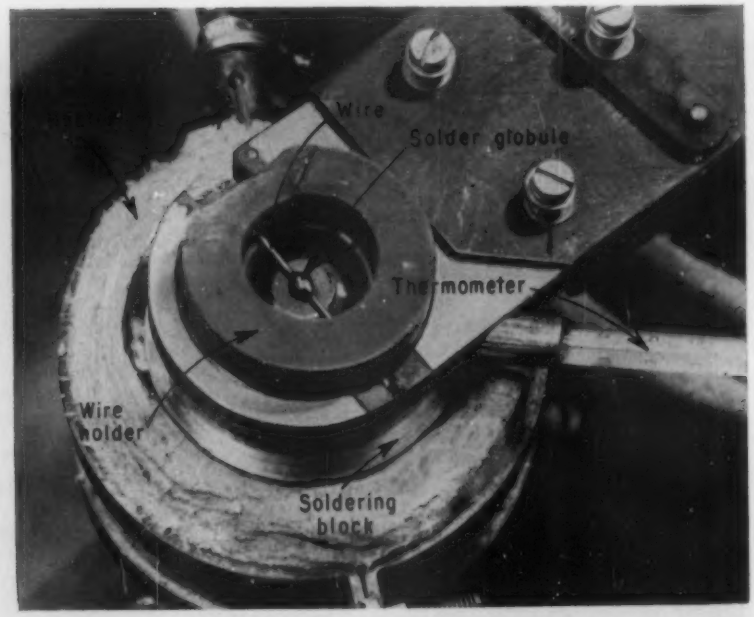
Pinpoints Best Soldering Conditions

By focusing on one variable at a time, this versatile test apparatus provides precision needed for faster soldering. The variables it checks are temperature, surface condition of metal, composition of solder and flux.

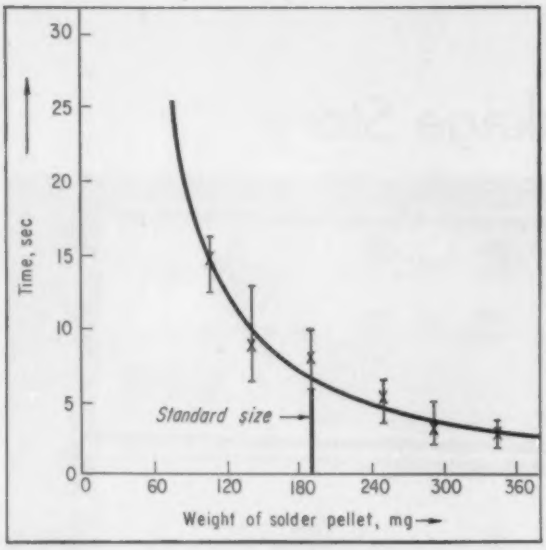


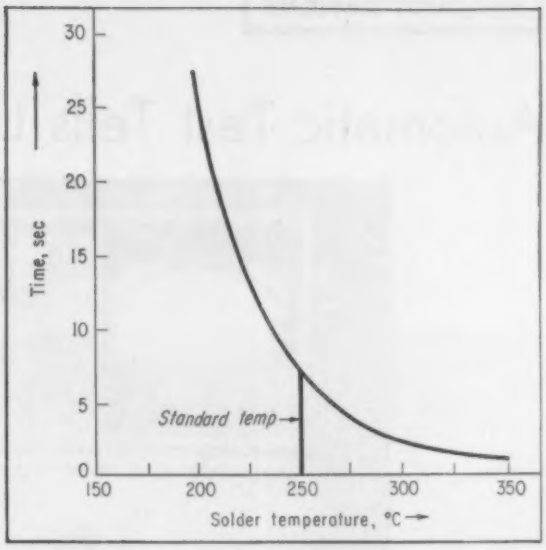


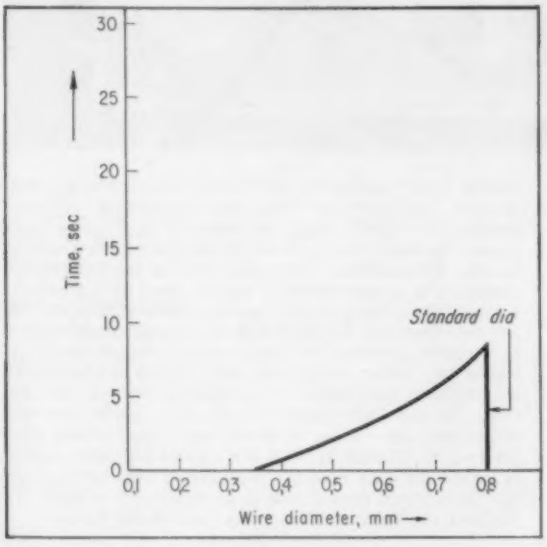




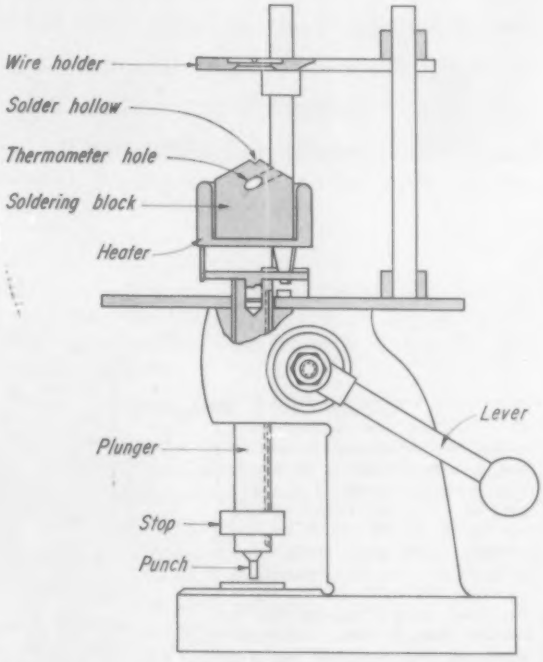
SOLDERABILITY IS RATED by time needed for a drop of solder to flow around a wire of the metal under test. First, a measured quantity of the solder is heated in a hollow in a chrome-plated chrome-nickel steel block. The solder does not wet the block and remains in the hollow in globule form (A). Next, the test wire is dipped in flux and clamped in the ring above the soldering block. The block is then raised so that the wire cuts the solder globule in two (B). The solder creeps up around the wire at a speed that depends on such variables as solder composition, flux, temperature, etc. The moment when solder engulfs the wire occurs abruptly, and can be observed precisely (C). Time elapsed between splitting the globule and its flowing together again is measured with a stop watch. The shorter this soldering time, the better solderability. Recorded results show excellent correlation between test samples and production runs.







STANDARD CONDITIONS, set up to permit checking each variable, are so selected that they will produce a long enough soldering time for observation of the influence of different factors. The selected conditions are: a pellet of solder measuring 22.4 cu mm (0.001,37 cu in.); temperature of 250 C; copper wire, 0.8 mm (0.0312 in.) dia; and flux consisting of 40/60 rosin/alcohol mixture. Under these conditions a soldering time of approximately 7 sec is normal. Solder composition used is 60% tin, 40% lead; the wire is degreased in trichlorethylene and acetone.

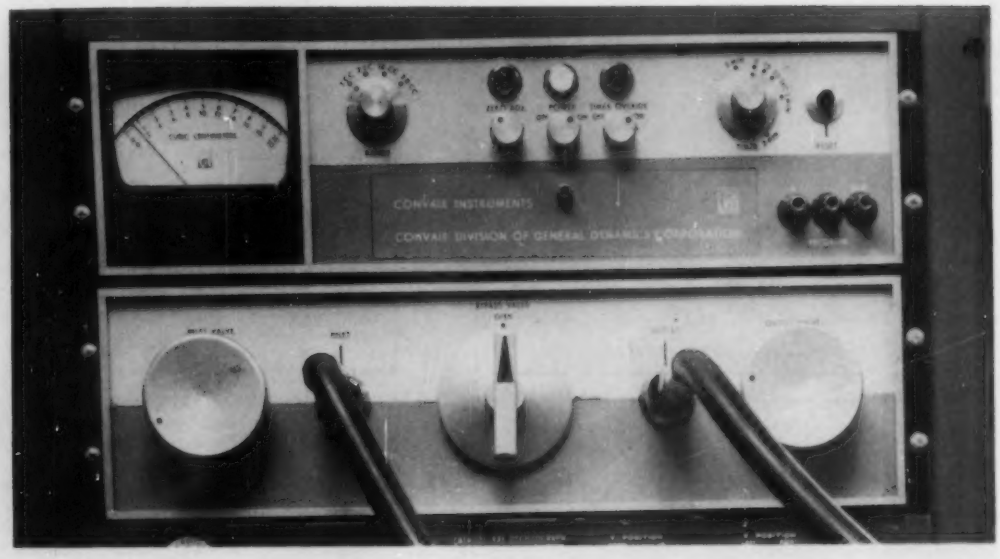


TEST APPARATUS resembles a small bench press with the heated soldering block mounted atop the plunger. Lower end of the plunger, which punches the standardized solder pellets used in testing, has a stop that fixes test position for the soldering block. The electric heater is controlled by rheostat, and a mercury thermometer checks temperature. Salts of known melting point are used to determine temperature correction for the remote thermometer reading.

Dimensions of the hollow that holds the solder globule determines its shape. The standardized 22.4 cu mm (0.001,37 cu in.) solder pellets are suitable for testing wire of 0.5-1.0 mm (0.02-0.04 in.) dia.

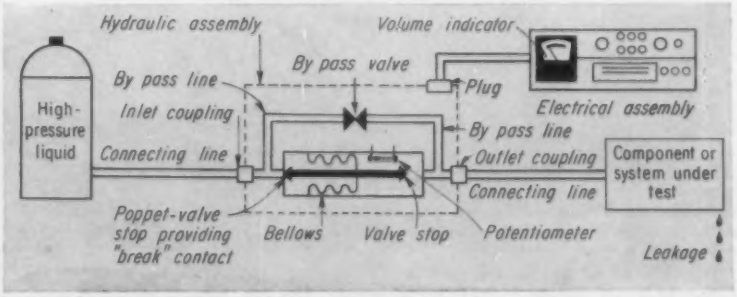
PS . . . The tests is especially valuable for dip-soldering of printed circuits. This low-temperature soldering needs precise control of all variables to assure electrically and mechanically sound joints. For example, adding as little as 1% cadmium or zinc can lengthen soldering time to more than 30 sec. Tester was developed by N V Philip Gloeilampenfabrieken, Eindhoven, Holland.

Automatic Test Tells Leakage Story



Just connect a hydraulic line from component to panel, and set the timer. Unit then automatically measures any leak flow—no need to catch escaping fluids, and environmental conditions do not affect result.

LEAK TEST begins by connecting the unit under test to the leakmeter at the quick-disconnect coupling marked OUTLET. Only a hydraulic line joins component to meter, so result is unaffected by environment of item being tested. A second coupling marked INLET connects to a high-pressure source such as a pump or accumulator. This provides a completely closed system. After connection, the inlet and outlet valves are opened to equalize pressure in the system. Measurement is begun by closing the bypass valve which automatically starts the preset timer. If a leak is present in the system, the red light goes on and the volume indicator starts moving. This continues until the preset time interval is concluded; then the volume-indicator needle is locked for easy reading. The instrument can be held in this position indefinitely at pressures up to 5000 psi. Opening the bypass valve resets the volume indicator.



BYPASS VALVE diverts leakage flow around the measuring bellows until timer starts. When this valve is closed the bellows moves in response to any leakage from the component under test. A rectilinear potentiometer indicates bellows movement by producing a voltage proportional to volumetric displacement of the bellows. This voltage is shown on the volume indicator. When the bellows is in its undeflected position, the poppet-valve stop keeps the red indicator light shorted out. Any movement of the bellows breaks the contact and lights the indicator lamp.

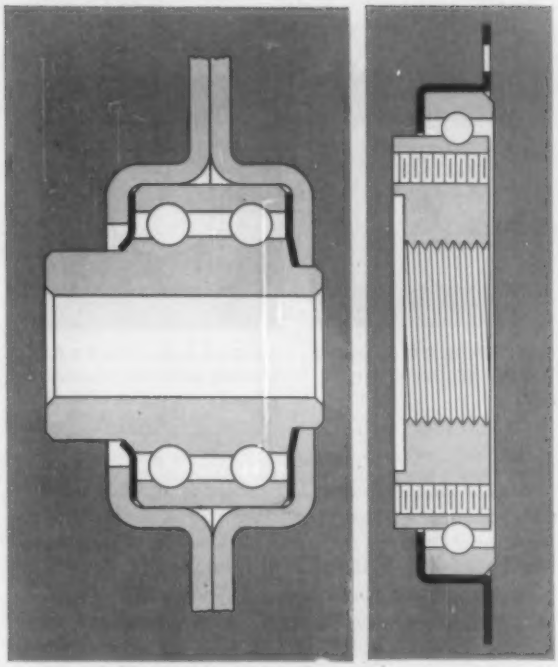
PS . . . Timer and volume-indicator ranges can be adjusted to measure leak flows from 0.008 to 80 cc/min. Time intervals available: 5, 2 and 1 min.; 30 and 15 sec. Volume indicator can be set for 20, 10, 5 or 1 cc full-scale. Leak flows smaller than 0.008 cc/min. can be measured by overriding the timer and running a longer test, using a separate clock to indicate elapsed time. Leakmeter Model 400 was developed and produced by Convair Instruments, Convair Div of General Dynamics Corp, San Diego, Calif. Appearance of the instruments was designed by Zierhut-Vedder-Shimano, Van Nuys, Calif.

INTEGRAL BALLBEARINGS—

new approach to product improvement

Although conventional ballbearings are made in a wide range of sizes, you can benefit in many applications by turning to the integral type, inner or outer race.

FRANK H STEARNS, *chief engineer, Split Ball Bearing Div*
Miniature Precision Bearings Inc, Lebanon, NH



TYPICAL INTEGRAL BALLBEARINGS using split ballbearings with fractured outer race.

Incorporation of the inner or outer ballbearing race as an integral part of the product can result in longer bearing life, lower maintenance, fewer parts, higher precision, and lighter weight. The problem is to decide which race can be most advantageously incorporated into the product. The ideal combination of bearing and product components needs careful analysis by both the bearing and product manufacturers. When a race is designed to serve a dual purpose its estimated life must be correspondingly greater in order to justify its increased cost over a plain ballbearing race. Usually, these disadvantages are more than offset by the advantages.

Longer bearing life results from the fact that these bearings contain a larger number of load-carrying balls in a given space. Maintenance costs are lower because they are more accessible. By incorporating one of the races into the product, fewer parts are required. Since there are fewer concentric surfaces that must be held to close tolerances and concentricity, higher precision can be applied to these. Also, more conservative envelope dimensions can be applied to these fewer parts. Where low torque is more important than load characteristics, the greater ball capacity can serve to lower the bearing torque by making the alternate balls undersize.

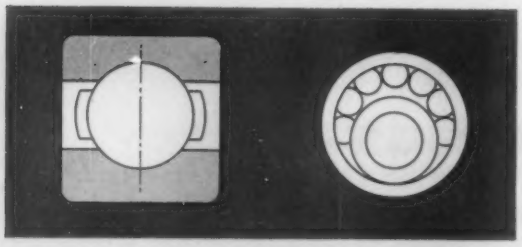
FILLING THE RACE

Conrad Bearing has continuous race shoulders, and good radial and axial thrust capacities. However, the race is only about half-full of balls—limit that can be assembled with eccentric loading and multi-piece retainer system.

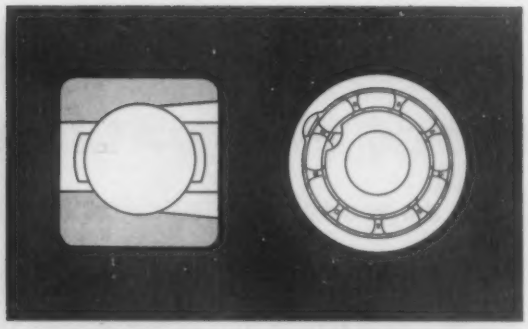
Loading-slot Bearing is similar to Conrad but employs slots or loading notches in the inner and outer races to reduce the displacement required in assembly. This increases the number of balls, but the loading slots make it unsuitable for high thrust loads. Also, a multi-piece ball retainer is required, which restricts the number of balls since space must be left between them for the retainer as well as the assembly operation. This means that a full ball complement is infrequent in this type.

continued, next page

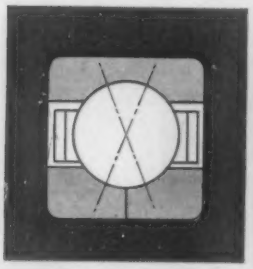
REPRINTED—Circle P46, inside back cover



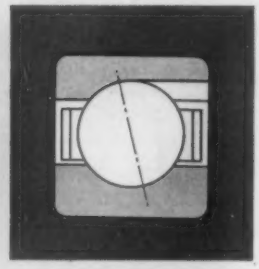
CONRAD BEARING with inner race in eccentric position for loading.



LOADING-SLOT Bearing with multi-piece retainer.



TWO-PIECE Inner-ring Bearing is center-cut.



ANGULAR-CONTACT Bearing with one shoulder of outer race removed.

FRACTURED-race Bearing with outer race split at one point for loading.

Angular-contact Bearing has one outer race shoulder completely removed, to permit assembly of a maximum number of balls with a one-piece retainer. It is useful only where there is a relatively high thrust from one direction producing angular contact.

Double-row Bearing can be made similar to any of the above single-row types, with corresponding advantages and disadvantages. In this type of bearing, axial thrust and radial loads can be increased appreciably, but more space is required.

Two-piece-ring Bearing (either outer or inner) is essentially an angular-contact bearing capable of high thrust loads at high speeds. However, it is complicated, and application becomes increasingly difficult as radial exceeds thrust load. Result is these bearings are limited to applications with heavy thrust loads in either direction.

Fractured-race Bearing has the outer ring scored and fractured so it can be opened to introduce a maximum complement of balls. The opened ring closes elastically and is secured in place by various methods, depending upon the application. This permits the advantageous use of a precision one-piece retainer of any suitable material where ball separation is required.

This type of bearing is also made with both inner and outer races fractured for applications where a conventional solid-race bearing cannot be used. (This technique is more fully described in "Split Ballbearings . . . and When to Use Them," July, 1954, p 197.) Double-fracture type is also advantageous where maintenance costs need to be reduced by simplifying replacements without disassembling many other parts of the machine.

Recently this fractured-race technique has been extended to include double-row bearings, thus widening the application possibilities to a full range of speeds and loads encountered by conventional ballbearings. Table I supplies a comparison of the characteristics of split ballbearings with journal and conventional ball and roller bearings.

To summarize the characteristics in this table: (1) The sliding-type bearing has reasonable load capacity and unlimited life, operates best at high speeds, and can be very economical in large-production items. However, when the limited load characteristics are exceeded, severe damage may result to shaft or housing. (2) The conventional ball and roller bearings have outstanding load-carrying capacity, can operate at reasonably high speeds, but are best for relatively low speeds. (3) The split ballbearings have all the characteristics of the conventional ballbearings, with the added advantage of a greater number of balls in a given space. This advantage is reflected in the various characteristics in Table I.

The next table gives a comparison of dynamic load capacities for split ballbearings and conventional bearings. These are minimum values, but higher values are possible with variations in ball or roller size and other design factors. These are general values. For more specific comparison of such values and pertinent design factors, the catalogs of the individual manufacturers should be consulted.

WHEN INTEGRAL BALLBEARINGS?

The tables show characteristic advantages for split ballbearings which are great enough to overcome the inherent difficulty of incorporating one of the races as an integral

text continued on page 50

I—OVER-ALL COMPARISON AMONG TYPES OF BEARINGS

Characteristic	Journal Bearing (sliding)	Conventional Ball & Roller Bearings	Split Ball-Bearings
Load			
starting	Poor	Good	Excellent
cyclic	Good	Excellent	Excellent
shock	Fair	Excellent	Excellent
Speed Limited By	Turbulence Temperature rise	Centrifugal loading Dynamic effects	Improved loading and dynamic effects—more balls in given space
Misalignment Tolerance	Fair	Poor in ballbearings except where designed for at sacrifice of load capacity; good in spherical roller bearings; poor in cylindrical roller type	Good, due to continuous race shoulders and max number of balls
Starting Friction	Poor	Good	Excellent when alternate balls are undersize
Space Requirements			
radial	Small	Large	Large
axial	¼ to 2 times shaft dia	1/5 to ½ shaft dia	1/5 to ½ shaft dia
Damping	Good	Poor	Poor
Noise	Quiet	May be noisy, depending on quality of bearing and resonance of mounting	Good, due to misalignment tolerance
Power	Varies as $\frac{N^2D^3L}{C}$	Varies widely depending on type lubrication; varies directly as speed; usually lower than sliding bearings	Lower than conventional bearings—alternate undersize balls give lower torque
Life	Unlimited, except for cyclic loading	Limited by fatigue properties of bearing metal	Limited, but longer than conventional ballbearings for same speed and load
Cost	Very small in mass-production quantities or simple types	Intermediate, but standardized, varying little with quantity	Similar to conventional type for same load and life characteristics

II—DYNAMIC CAPACITIES OF BALL AND ROLLER BEARINGS, LB

Bearing Bore, mm	Deep-groove Ballbearings				Angular Contact (thrust rating)			Cylindrical Roller Bearings		Split Ballbearings			
	19xx	01xx	02xx	03xx	72xx	73xx	74xx	N2xx	N3xx	19xx	01xx	02xx	03xx
10	465	750	805	1,340	1,320	1,550				654	1,010	1,500	1,890
12	495	812	1,170	1,340	1,490	1,550				738	1,095	1,510	2,040
15	745	880	1,320	1,940	1,690	2,440				935	1,440	1,650	2,710
17	790	950	1,480	2,330	2,450	2,980	5,590			976	1,540	2,040	3,180
20	1,100	1,510	2,190	2,550	2,840	4,070	7,550			1,410	2,090	2,730	3,500
25	1,130	1,660	2,420	3,650	3,420	4,750	9,200	2,450	5,200	1,560	2,700	3,100	4,970
30	1,250	2,200	3,350	4,800	3,790	6,280	11,900	4,050	6,800	1,635	3,050	4,300	6,350
35	1,650	2,650	4,440	5,700	5,310	7,950	14,000	5,850	8,800	2,610	3,690	5,700	8,200
40	2,100	2,850	5,050	6,950	6,980	9,880	16,300	7,650	10,400	2,830	3,940	7,080	
45	2,270	3,550	5,650	9,000	6,990	12,000	18,700	8,000	14,300	2,960	4,800	7,600	
50	2,310	3,750	6,050	10,400	7,640	16,300	22,700	8,300	17,000	3,080	5,460		
55	2,880	4,800	7,450	12,000	11,000	18,900	25,600	10,200	20,800	4,450			
60	2,960	5,100	9,050	13,700	12,000	21,700	27,900	12,500	23,200	4,560			
65	3,010	5,300	9,900	16,000	14,500	24,200	30,300	14,600	26,000				
70	4,100	6,550	10,700	18,000	15,700	24,700	37,200	14,600	30,500				

component of the product. Until the recent extension of split ballbearings into the integral ballbearing field, this design concept was largely limited to roller and needle bearings, which are much easier to integrate into the products.

Actually, integral roller and needle bearings have found wide applications in Europe since shortly after the last war. Integral ballbearings, however, have been confined to isolated cases that could not be solved in any other manner. A typical example is the experimental aircraft engine that kept on improving power output to a point where shaft diameters had to be increased appreciably, but overall dimensions and weights were "frozen." This created a serious problem for bearing designers, because space limitations did not permit using conventional ball or roller bearings of adequate size. The problem was solved by incorporating the outer race as an integral part of the housing. Such cases have brought increasing acceptance of integral ballbearings as a means for creating new product advantages. The obvious advantages of ballbearings over roller bearings in regard to load characteristics have served as incentive to adapt them to the proven concept of integral roller bearings.

MAKE OR BUY?

The components that concern the bearing itself usually are best made by the bearing manufacturer, because of the specialized experience and equipment needed. This assures the proper clearances and tolerances that determine bearing life. However, if your plant has considerable experience in design and manufacture of precision machine parts, such as ballbearings, you will likely want to manufacture as much of the integrated bearing as possible. Usually, the best procedures are made in a conference between the bearing and product manufacturers. This will also assure proper assembly procedures for the ballbearing and the product.

For REPRINT of above article, just check P46 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: For additional information on bearings see:

Gas Bearings, Nov 23 '59, p 68. Report on First International Symposium on Gas Lubricated Bearings. These bearings feature fantastic speeds, high accuracies and very little friction.

These Methods Test Performance of Ballbearings, Sep 14 '59, p 78. Gives description of special and commercial devices to check torque, vibration and runout characteristics.

Unusual Applications of Miniature Bearings, Nov '56, p 184. Sketches and description of 8 applications that are suggestive of numerous other possibilities.

Guide to Lubricants for Instrument Ballbearings, June 9 '58, p 66. Gives properties and performance characteristics of 42 lubricants suitable for instrument bearings, with a review of significant military specifications.

Instrument Bearings for 300 F and Up, Feb 3 '58, p 72. Discusses silicone greases for high-temperature applications, and effects on bearings.

ECCENTRIC VIBRATOR AVOIDS HIGH BEARING LOADS

In a new vibrator for fluid concrete —developed by Pacific Mercury, North Hollywood, Calif—eccentric forces that move the vibrator head are produced by a single large steel ball chased around its race by an off-center tang on the motor shaft. The motor is a universal type, designed for 14,000 rpm; ball race, ball and motor are sealed within a housing that is watertight.

This design develops the desired vibrating displacement of the housing without the high bearing loads involved in the conventional method of rotating an eccentric shaft-mounted weight.

Tang on the motor shaft is itself dynamically balanced; load on motor shaft is torsional and steady. Motor bearings therefore are not subject to excessive loads.

Vibrators are needed for this particular service to drive air out of the concrete and obtain a higher strength slab. Since the power head needs only infrequent service, the unit is designed for effective sealing against immersion. The only connection needed is an electrical power cord; earlier designs with off-center weights were driven by flexible shafting from a separate motor, and required frequent bearing replacement.

Only lubricant required by the heavy ball is a dip in SAE 20 oil before assembly. Motor has a built-in overload device, and is rated for continuous operation when submerged, using the concrete as a heat sink.

Hand lay-up is the oldest and simplest technique for fabricating FRP parts. A mold is constructed of wood, epoxy resin, plaster or other easily worked materials. Mold can be either a cavity or a positive shape. If a cavity is employed, and a smooth finish on the part is required, a thin coat of resin is sprayed into the mold to form a gel-coat. Chopped-strand mat or woven cloth is then laid into the mold by hand — carefully tailored if necessary — and catalyzed resin applied by brush or spray gun. Curing takes place in air, in a vacuum bag, or in an oven. Autoclave curing permits higher glass concentrates. Hand lay-up finds use in large structures — as well as in prototyping, and for low-volume production.

DON'T OVERLOOK HAND LAY-UP

Often forgotten amid newer and more spectacular processes, the granddaddy of them all continues to thrive when design calls for large size, high strength, and superior surface finish. Here's your design guide for this versatile process.

JAMES S LUNN, *president*
Lunn Laminates Inc
Huntington Station, NY

Hand lay-up, along with its related process, bag molding, retains its vitality as a fabricating process for reinforced plastic parts because of three key advantages over other techniques:

1. Large and complex parts, impossible to press-mold or to spray-up, can be readily constructed.

2. High strength through high glass content is possible, and the fibers can be oriented in local areas as stress distribution demands.

3. Frequent style changes are easily effected.

Hand labor, in conferring these advantages, also imposes some limitations: production rate is necessarily limited, and much of the money saved by not making metal dies goes into increased labor costs—particularly where multiple molds are used to boost production rate; skilled labor is a must to get uniform glass/resin ratio and parts free of wrinkles and bulky laps; cloth used for hand lay-up is an expensive glass form, though a cheaper type—woven roving —is being more widely used. These advantages and limitations should be weighed before selecting hand lay-up.

The two most common engineering situations that will

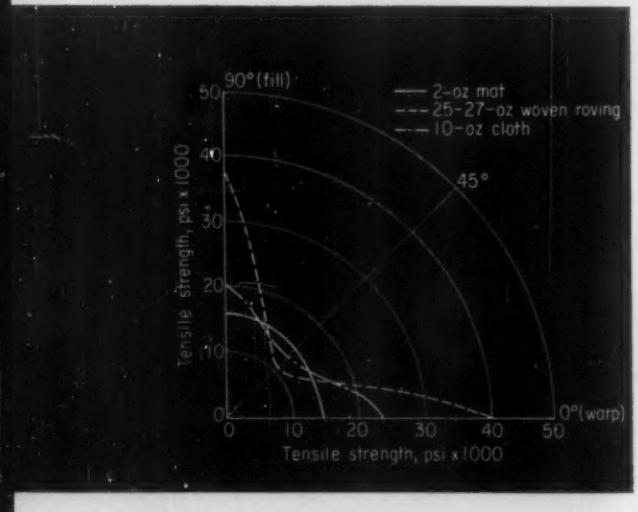
Table I—REINFORCEMENTS FOR HAND LAY-UP

Type	Advantages	Limitations
Glass mat	Low cost Isotropic Good interlaminar shear Mold to complex shapes	Laminate thickness hard to control Glass content hard to control Gives fibrous appearance Gives low glass content
Woven roving	Good drapeability Gives high glass content Adds impact resistance Good for thick laminates Good local reinforcement	Hard to wet out Tends to trap air bubbles Tendency to resin-rich areas Strong only in 2 directions
Glass cloth	Improves surface appearance Adds glass to mat laminates Properties very consistent Good local reinforcement	Cost is high Laminates weak in shear Thick sections take many layers

Table II—TYPICAL PROPERTIES OF PRODUCTION LAMINATES

(General-purpose, rigid polyester resins)

Property	Reinforcement and Molding Method				
	2-oz. mat		10-oz. cloth		Woven roving
	Contact	Vacuum bag	Contact	Vacuum bag	Contact
Specific gravity	1.31	1.50	1.63	1.67	1.64
Glass content, %	23	38	46	50	51
Tensile strength, psi x 1000	16	18.6	24.1	24.2	33.0
Tensile modulus, psi x 10^6	0.91	1.17	1.95	1.94	2.06
Flexure strength, psi x 1000	20.5	27.1	31.1	35.3	27.1
Flexure modulus, psi x 10^6	0.85	1.24	1.96	1.97	1.81
Compressive strength, psi x 1000	16.9	22.4	18.9	21.7	17.0
Compressive modulus, psi x 10^6	0.93	1.16	2.46	1.55	2.45



DIRECTIONAL NATURE of the FRP properties is clearly shown in these tensile strength curves for wet laminates made from three different types of glass reinforcement: mat, cloth and woven roving. Note that mat gives closest approach to isotropic material, but strength is low; woven roving gives max strength, but profile is highly directional; cloth gives best balance of both, should be used where biaxial stress is a problem. Facing layers of cloth on cores of mat or woven roving improves strength 10-20% in the warp direction (0°) only, has no appreciable effect on directionality. All laminates here were laid up in parallel direction; properties in 45° directions can be improved if laminations are placed at right angles and at intermediate angles as well. Common intermediate angles: 45° and 135°.

lead you to specify the hand lay-up technique are these:

A short lead time is required. Even with parts that might be press-molded, hand lay-up can often deliver parts before dies can be designed and ordered. Intermediate production prior to receipt of dies can be achieved simply by making, via hand lay-up, more than one mold.

Reinforced plastic seems better than metal for the job. Hand lay-up is a low-cost way for the metals-oriented designer to try fiberglass-reinforced plastics for the first time. This can be important because the FRP's have a high price tag per pound, much higher than metals. Thus the "initial cost inertia" factor many times obscures the long-run money-saving advantages of these materials. A fabrication process that minimizes tooling commitment, as hand lay-up does, can often show the way to unexpected savings.

To exploit hand lay-up's three key advantages in either of these two situations, parts should be designed with the process very much in mind. Here is a summary of good design practice for structures fabricated by hand lay-up, a summary based on experience with the process on parts of all sizes—both commercial and military.

Materials. Hand lay-up parts, often called contact moldings because they are made in open molds with no shaping pressure during cure, contain from 20 to 60% glass depending on the form of glass reinforcement. Three basic forms are employed, each with major advantages and limitations: glass mat, woven roving, and glass cloth—in order of increasing cost. Rovings are straight bundles of glass strands somewhat like an untwisted rope. They can be woven with most of the glass in one direction, for maximum directional strength, or in a square pattern, with strength about equal in warp and fill directions. Choice of glass form depends largely on considerations of strength, cost, and ease of fabrication, Table I.

Polyester resins make up the bulk of plastics used, principally because they are easy to handle, relatively inexpensive, and available in a number of types—from rigid to fairly flexible—to meet most structural applications. Epoxies, though more expensive and somewhat harder to handle, are gaining favor—especially in designs requiring exceptional corrosion resistance or high hot strength, and as preimpregnating resins. Epoxies have long been used as fill-in materials in hand lay-up structures, and bond well to polyesters. Choice of both glass form (or combination of forms) and resin is usually made in close consultation with the fabricator, who is usually expert on materials.

Mechanical properties. Sometimes there is hesitancy about specifying the FRP's as engineering materials because their properties must be designed along with the part shape. But too much has been made of this problem. It is true that only laminates made with mat are close to isotropic, and that mat laminates are the weakest of all. However, extensive testing on laminates made in production situations has shown that consistent properties are easily achieved with all glass forms. Table II summarizes realistic properties achievable using three basic glass forms with hand lay-up and with vacuum-bag molding. These values can be used with confidence in design with an appropriate safety factor—usually about 2.

For borderline stress problems, directionality of properties becomes a factor. Different glass forms produce differing degrees of directionality; see curves on facing page. For detailed procedures on designing composite laminates, taking directional properties into consideration, see the recently published *Marine Design Manual*, McGraw-Hill, Chapter 6.

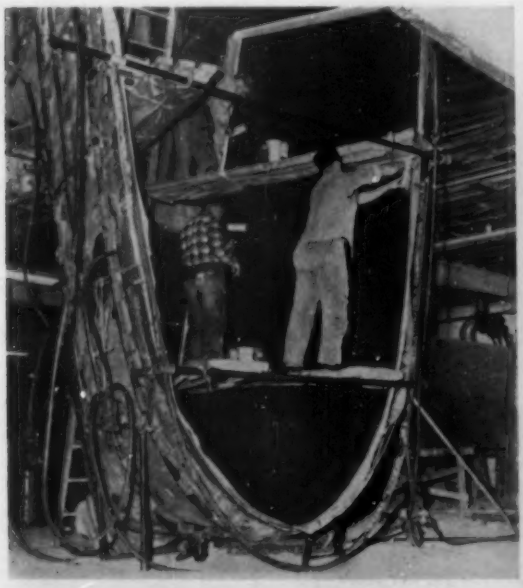
Construction. One key advantage the FRP's have over metals is that they lend themselves to one-piece fabrication, thus cutting out much assembly labor. But this advantage can be pressed too far; design of the part must permit easy access to all points for the fabricator—for whom there are definite body-movement limits. Ignoring this factor inevitably runs up jig and tool costs.

Breaking down monolithic reinforced plastic designs into a few large subparts raises the fit-up problem. If money is available for precise open molds, hand lay-up will produce mating parts that can be duplicated with the same precision as matched-die molded parts. If, however, less money is available for tooling, best fit-up is achieved by specifying adjacent parts to be made in succession against one another. Since each part is laid up to one that has already been cured, fit-up is assured.

Joints. Most joining of FRP subassemblies is based on adhesive bonding, using the base resin itself as the adhesive. A wet layer of glass and resin laid up against an already cured one will itself cure and form an intimate bond—just as though the two layers had been prepared simultaneously. Akin to welding, this technique gives joints as strong, if not stronger than the parent material. Typical joint designs are shown in Table III, next page.

Mechanical fasteners and true adhesive bonding are specified when geometry does not permit joining by lay-up, when one half of the joint is metal, or when unusual stress concentrations are present. Bolts and self-tapping threaded fasteners are most common. To prevent tear-out, they should have free edge distances of 2.5 times the fastener dia and a spacing of 3 diameters. FRP is weak in bearing, thus bolts should be selected oversize or sleeves should be specified where possible to give maximum bear-

text continued on page 55



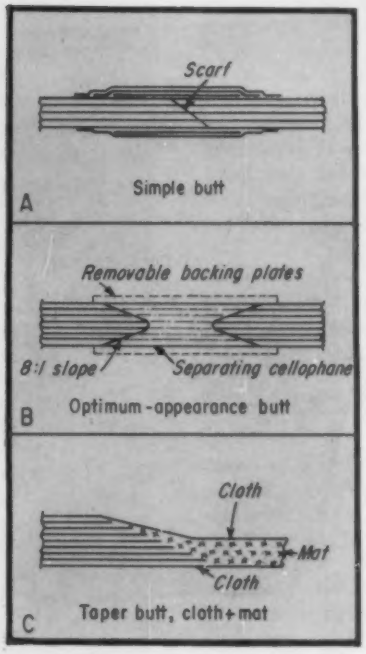
Vacuum Bag Makes High-quality Lay-ups

Higher glass content and more uniform thickness are the two key features of parts constructed by vacuum-bag technique. After layers of glass fiber and resin are laid up in open mold, a thin transparent plastic sheet is placed on top and the air evacuated from beneath it. Atmospheric pressure then compacts the mix, forcing air bubbles out. Hand-rolling, as shown in photo at left, assists in removal and achieves max density. In this photo, a submarine sonar nose is being rolled out; note simple mold of reinforced plastic backed up with tubular frame. At right, finished sonar nose on USS Skate. Pressure-bag method uses higher pressures, 15-40 psi, and requires a stronger mold. Autoclave technique adds heat for faster cure along with higher pressure, 25-100 psi.

Table III—TYPICAL JOINTS FOR HAND LAY-UP

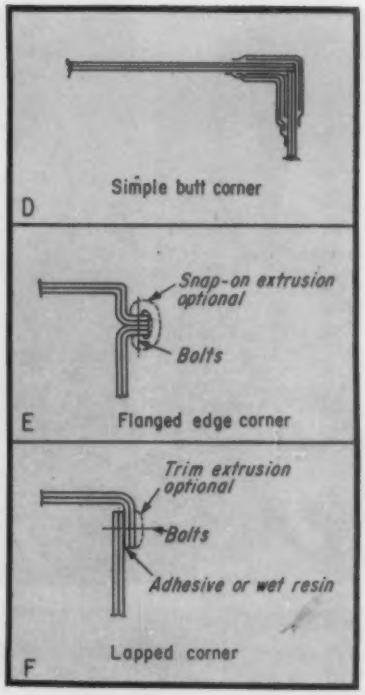
3 butt joints ▸

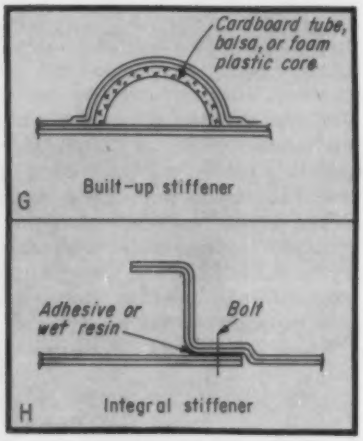
Butt joints are the weakest type in hand lay-up parts, hence require care in design and execution. When premolded sheet is joined, as in (A) and (B), edges are angled (scarfed) to give more bonding area for distribution of stresses. Precise number of layers for simple butt (A) depends on loads involved and surface appearance required. For a smooth surface, a double-scarfed joint like (B), cured between removable plates, is specified. Or economy may require connection of a heavy cloth laminate to a thinner mat section. Here, a joint like (C) can be laid up by stepping the cloth layers, and laying the mat layers over the steps. Cloth outer layers add strength and rigidity to the joint.

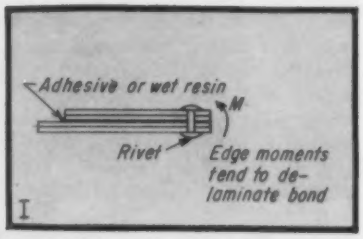


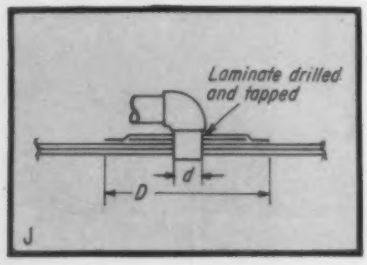
3 corner joints ▸

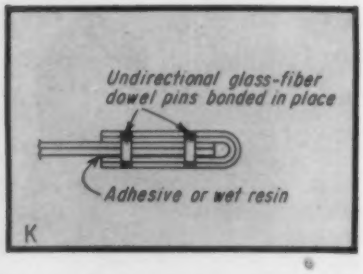
Corner designs are many, but reduce to the three main types shown here. Since corners are subject to much flexing they require local reinforcement where possible. Joint (D) is the simplest, using premolded sheet reinforced with layers of glass cloth and resin. For added strength, a wood or metal angle, bolted in place, can be substituted for the inside layers, or the butt itself can be carried around the corner by curving one of the mating pieces. Though bolts are shown in these sketches, self-tapping screws as well as rivets can be used. Joints (E) and (F) are designed for mechanical fastening and require trim to hide the edges if finished appearance is desired. Best procedure of all is to design the corner integral with the structure so that no joint is needed.

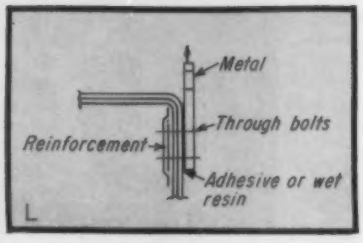












◂2 stiffeners

Stiffeners are easily built into hand lay-up structures as long as they are (1) planned for at the design stage, and (2) designed so that the loads they carry are well distributed into the surface they reinforce. Two main types are (G) and (H). Built-up stiffeners on contoured surfaces can use cores of cellular cellulose acetate (CCA), which is somewhat flexible. Integral stiffening is most easily incorporated as flanges at a joint—combining two functions in one configuration. As in weldment design, pads and/or gusset-plates are desirable where stiffeners intersect a flat, flexible area—to distribute loading evenly.

◂preventing edge peel

Peeling tends to occur where two laminates lap together at a free, much-handled edge. One laminate can be laid up against a premolded one, or two premolded pieces can be joined by adhesive bonding. In either case, a mechanical fastener (I) will prevent peel. Other methods: Locally increase the bond area of one laminate near the edge, wrap one laminate complete around the edge of the other, or locally increase the thickness of one laminate at the edge.

◂pipe fittings

Pipe fittings attached to flat or nearly flat surfaces induce local moments in the surrounding laminate, as do lugs and support brackets of various types. To stiffen the laminate, and to provide thickness for threading in the fitting, a reinforcing ring should be laid up as shown in (J). The ratio D/d should be in the order of 6 to 10; large values for reversed loads.

◂hinges

Hinges made entirely of glass-reinforced plastic are not too common, but present difficulties when required. One obvious approach is to wrap the laminate around a pin, as a metal hinge is made, but this gives rise to eccentric loading and possible delamination of the lap. Another way is to thicken the edge of one laminate with additional laminations top and bottom, then drill parallel to the layers of glass cloth. Here, pull-out occurs. Best technique is (K).

◂metal lifting lugs

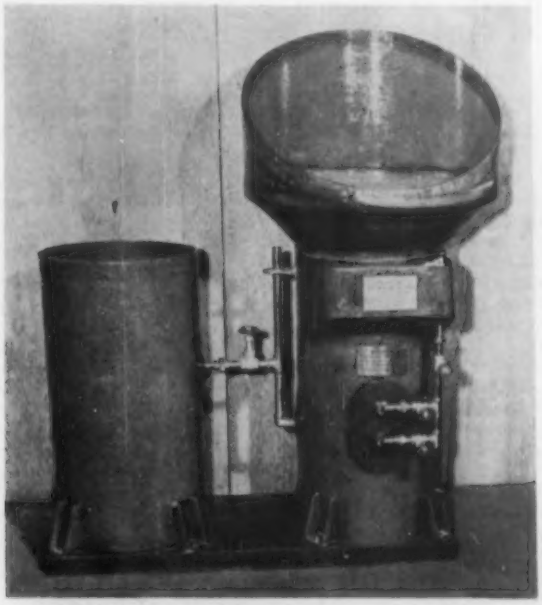
Lifting lugs should be metal, since FRP is generally poor in bearing, and lifting cables, hooks etc are very concentrated loads. One design is shown in (L): mechanical fasteners tie lug to laminate, with additional layers added locally to spread the load. Where possible, locate the lug near a reinforced portion of the structure, and always orient it so that loads applied to laminate are along the piles of reinforcement and not at right angles to them.

ing area. Much test work has been performed on the holding force of threaded fasteners. This data, and the method of using it to select correct fastener size, is summarized in the above mentioned *Marine Design Manual*, Chapter 3. For design of adhesive joints, see *Adhesive Bonding of Reinforced Plastics* by H. A. Perry, McGraw-Hill.

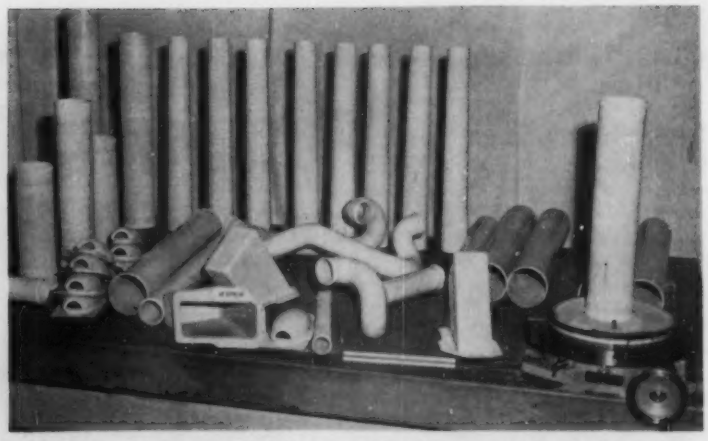
Stiffening. Because of its low modulus, reinforced plastic often requires stiffening against deflection on large areas. Simplest way, and often cheapest, is to increase total laminate thickness. Local stiffeners are easy to add by hand or lay-up, as shown in Table III, and should always be specified where localized loading occurs in the structure.

Sandwich construction provides efficient stiffening, but is expensive. Most common cores used with hand lay-up are paper honeycomb, foamed plastics like polyurethane and cellular cellulose acetate (CCA), and balsa wood. Where possible, core material is set in place against a freshly laid-up face. When this joint is cured, the second face is laid up against the core. With paper honeycomb, this procedure gives much higher peel strength compared to sandwich made with premolded faces.

For contoured sandwich panels, CCA can be cut in strips and fitted to the freshly laid-up facing like brick, with a mixture of resin and vermiculite as "mortar." Paper honeycomb presents a greater problem, since it is formable only to a limited degree and will spring back. For simple contours, a templet-and-lathe form can be built, and the paper honeycomb pulled to it with hooks. Then the first



CORROSION RESISTANCE is an important feature of reinforced plastics, which play an important part in chemical-handling equipment like this rock-salt dissolver made by DuVerre Inc. Here, structural loading is low, so glass-fiber mat is the reinforcement instead of cloth—thus saving money. Note that many design features are adapted directly from welded sheetmetal practice for this device.



TWO UNUSUAL HAND LAY-UP TECHNIQUES make FRP ducts having high strength/weight ratio. (1) Twisted duct for helicopter (left) is made on collapsible, rectangular cross-section mandrel. Walls are 0.020 in., and require local stiffening to prevent flutter; note also rivet at edge of metal tab, added to prevent peeling. (2) Tubular ducts for aircraft are made by conventional lay-up procedures, but with Mylar tape wrapped around the wet mix to provide pressure for best properties. Tape is stripped off after ducts partially cure.

face can be laid up. Vee joints, where two pieces of honeycomb come together, are filled with resin-vermiculite. The whole structure, properly supported, is then turned over and the second face laid up. Foam-in-place urethanes can be used as cores, too, but require careful controls to prevent voids, and heavy fixturing to take foaming pressures.

Surface finish. Appearance of hand lay-up parts depends on the type of reinforcement. Reinforcing mat and woven roving show the most pronounced glass-fiber pattern; cloth and surfacing mat show less and are often specified as a top layer for this reason. Cloth adds surface strength, too. Increasing pressure by going to vacuum-bag molding makes surface even smoother. Best surface, however, is obtained by spraying the mold with a thin coating of resin before hand lay-up begins. This can only be done with the side toward the mold. One solution for the other side is to make the final layer with a glass cloth that has not been chemically treated for maximum bond. Stripping this layer off after cure leaves a smooth matte surface ideal for priming and painting.

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Your Reference File on Glass-reinforced Plastics

The preceding article completes our planned series presenting design data on each of the seven basic processes for producing glass-reinforced plastic parts for commercial volume applications. A 64-page reprint including the entire series with all original text, tables and illustrations is in preparation and will be ready for distribution on May 10. Articles included in this combined reprint are:

Choose the Right Process for Fiberglass-reinforced Plastics, Jan 11 '60, p 47—Special report selects 7 key processes out of the 15 available, explains their strong and weak points.

Air Preforming with Matched Metal Dies, Mar 28 '60, p 74—How to design parts to take advantage of this economical process for production runs of 500 or more.

Wet Slurry Brings Precision to Reinforced Plastics, Feb 22 '60, p 52—Making preforms by dunking the shape you want into a slurry of fiberglass and cellulose gives improved control over thickness, density, and surface appearance.

Design Factors for Molding Glass Reinforced Parts, Mid-Sep '59, p 177—Ready-reference chart covers five processes specified for high-quality parts, shows design limits for each.

Design Must Be Different for Polyester Premix Molded Parts, Oct 12 '59, p 76—They can take the place of metals in many applications, but design follows different rules than for unreinforced plastic molded parts.

Sprayed Reinforced Plastics, Feb 8 '60, p 41—An economical process for making large parts from glass-reinforced plastic now bids for small parts.

Contour Weaving Gives 3-D Preforms, Mar 21 '60, p 47—Newest process for shaping fabric reinforcement gives high glass content, continuous fibers and controlled glass distribution.

Don't Forget Hand Lay-up, Apr 25 '60, p 51—Oldest FRP process has advantages when design calls for large size, high strength, and superior surface finish.

Filament Winding Grows Up, July 20 '59, p 46—After several succesful years in the aircraft industry, this high-speed process is ready for more work. Article gives rules for design.

Three New Epoxies Join the Prepreg Laminates, Aug 31 '59, p 38—This recently developed resin series combines good high-temperature performance with long shelf life, for preimpregnated glass stock.

What Fillers Will Do For the Latest Teflon, Sep 28 '59, p 52—Latest design data on filled Teflon 100X FEP-fluorocarbon resin, a new moldable thermoplastic.

High-impact Phenolic Molded Parts, Mar 7 '60, p 54—Author gives new rules for design, based on latest industrial experience with these materials.

High-temperature Reinforced Plastics, Nov 23 '59, p 58—What space-age testing is telling us about the fundamental behavior of reinforced plastics—the ablation story.

Copies of this 64-page combined reprint are $2.00, including postage. Send orders with remittance to Reader Service Department, Product Engineering, 330 W 42nd St, New York 36.

COULD YOU PASS A RUSSIAN HIGHSCHOOL EXAM?

Here's an idea of what is expected of Soviet students when they complete their 10-year study program.

FRANCIS E HALL
assistant editor

Of course you could pass—now. But how about when you were taking your own highschool exams for your diploma? When matching yourself with an 18-year-old Russian would-be engineer, here are two things to ask.

1. Could you have solved a physics problem drawn from any of the physical laws and concepts in mechanics, acoustics, heat, electricity, or optics? One like this, for example:

A container weighing 250 kg falls from a height of 800 meters. At a point 100 meters above the earth, what is its potential energy? What is its kinetic energy?

2. Just as important, could you solve the problem orally, in front of a panel of officials, with your future in higher education on the block? If you fail, your chance for a professional education is gone.

Until recently, Soviet primary and secondary education consisted of 10 years of schooling, six days a week. Reforms have added a year of manual work to the schedule, so that it now takes 11 years. At the end of the 11th year, students who have received marks of "3" (passing) or better for each subject taken, and a mark of "5" (excellent) in behavior, are eligible to take the State matriculation examinations. Those who pass the month-long comprehensive exams receive a certificate of maturity, prerequisite to higher education.

According to A. G. Korol, in *Soviet Education for Science and Technology*, which describes tests given in 1955, there are seven exams—five oral and two written. Since then there have been some changes, but the following is still representative of what goes on today.

The Ministry of Education publishes the examination material well in advance of the tests. The pamphlet contains a brief explanatory note and a set of questions, arranged by "bilety" (a system of cards on which questions are printed), for oral tests in literature, algebra, history, physics, and chemistry. Each subject contains from 21 (algebra) to 40 (history) cards; each card contains two or three questions. The pupils know the type to be asked, but not the specific problems.

QUESTIONS PICKED BY CHANCE

At the time of the exam, all cards are placed face down on the examiner's table. The student is called, he draws a card, and then has 15 to 20 minutes to organize his answers before facing the panel. At the price of lowering his mark by one grade, he can gamble and draw a second card. The panel consists of his teacher, the school director (or representative), a teacher from another school or class, and possibly two or three officials from the Ministry of Education.

Top students receive a gold or silver medal. A "5" in all subjects rates gold; "5" in all majors, and no worse than three "4's" in minors, rates silver.

NO ELECTIVES

Curriculum for the 10-year study program is established by the Soviet Ministry of Education. All students must take the same subjects—there are no electives, except for a choice of foreign language. Physics, algebra, and geometry are introduced in the sixth grade. Based on our 5 class-hours per week, all Soviet 10th-grade graduates have had the equivalent of about 3½ years of physics, 2½ years

of algebra, 2½ years of geometry, 1 year of trigonometry, and 2 years of chemistry. Other major subjects covered are biology (2½ years), history (3 years in grades VII through X), English, German, or French (4 years), and shop. Russian language and literature take a large proportion of time in the lower grades, and account for about a year in each grade, VII through X.

The last three years are on the college-preparatory level. Students who will be unable to attend college (either because they are incapable or for some other reason) are weeded out by the end of the seventh year. This is a European idea, not necessarily Russian. It has obvious advantages, but a serious disadvantage is that many "late bloomers" may be discarded before their ability is recognized. Some children do not "wake up" intellectually until they are in their teens or older. (Franklin Roosevelt, Churchill, Einstein and Newton showed little promise when young.)

Students who do not attend the final three years graduate in seven (corresponding roughly to our elementary school) and can go to work or attend a trade school or a "technicum." Technicums are "schools of specialized secondary education." They combine general education with vocational training at a subprofessional level. The trade schools turn out skilled craftsmen—plumbers, electricians, mechanics, carpenters, etc.

SOME SAMPLE QUESTIONS

Here are questions taken from some of the cards given in the Soviet examinations of 1958. The student draws one card for each subject. Each number below represents a separate card; all questions on the card must be answered. These samples will give you an idea of the scope of the material covered. There were 32 of these cards in physics, 31 in chemistry, and 26 in geometry.

Physics

1. (a) Derive the equation of the gaseous state. Give examples of utilization of gas laws in technology.
   (b) In the electrolysis of $ZnSO_4$, the work was completed in 10 hectowatt-hours. Determine the quantity of zinc produced if the voltage on the terminals of the vat was 4 volts.

2. (a) Explain the behavior of current in the rarefied gases; describe cathode rays and their properties, X-rays and their application.
   (b) A bullet is fired from a rifle at the speed of 865 meters a second. What will be the speed of the rifle's recoil, if its mass is 470 times that of the bullet? Why is it recommended that the rifle be held firmly against the shoulder at the time of firing?

3. (a) Derive the formula of the lens. Discuss: optical power of a lens; obtaining images with the aid of a lens.
   (b) A horse draws a cart weighing 500 kg up a mountain. The length of the incline is 1.5 km and the height is 100 meters. Determine the work accomplished by the horse against the force of gravity and the force of friction. If the coefficient of friction equals 0.06, what is the efficiency?

4. (a) Explain: continuous and line spectra; absorption spectrum; spectroscope; spectral analysis and its application.
   (b) Two little beads equally charged, each weighing 0.5 grams, and each suspended on silk threads 1 meter long, upon mutually repelling each other (after collision), have separated to a distance of 4 cm. Determine the amount of each bead's charge.

Chemistry

1. (a) Give classification and chemical properties of oxides.
   (b) In a laboratory, 105 grams of nitrobenzene were obtained from 78 grams of benzene during a nitrating reaction. What percentage of the theoretically possible yield is this amount?

2. (a) Discuss the most important phosphorus and nitrogen fertilizers, their composition, properties, and the chemical reactions involved in obtaining them.
   (b) How many litres of oxygen are consumed during the burning of one litre of: (1) methane, CH_4; (2) ethylene, C_2H_4; (3) ethane, C_2H_6?

3. (a) Describe the structure, physical and chemical properties, and applications of methane.
   (b) Fourteen grams of calcium oxide were treated in a solution containing 35 grams of nitric acid. How many grams of salt were found?

4. (a) Describe composition and applications of fats.
   (b) Obtain an assigned substance by means of an exchange reaction and separate it from the reaction mixture. Compute, on the basis of the reaction equation, what quantity of each of the initial substances is required for obtaining the indicated quantity of the product.

Algebra

1. (a) Explain: types of combinations and permutations; number of permutations of m elements taken n at a time; number of permutations of m elements.
   (b) Problem supplied at time of examination.
   (c) Discuss: quadratic equations, complete and and incomplete, and solution of quadratic equations of the form $x^2 + px + q = 0$.

2. (a) Discuss: equality of coefficients of terms equally distant from the beginning and end of Newton's binomial expansion; common term of the formula of Newton's binomial expansion; sum of binomial coefficients.

(b) Problem or example.
(c) Describe: expansion of a trinomial of second degree into linear factors.

3. (a) Explain: imaginary numbers; complex numbers; modulus of a complex number; condition of a complex number equaling zero, and of two equal complex numbers.
(b) Problem or example.
(c) Explain: exponential function; properties of the exponential function and its graph.

4. (a) State Bezout's theorem and its corollaries.
(b) Problem or example.
(c) Explain inverse-proportional relationship and its graph.

5. (a) Discuss solution of trinomial equations.
(b) Problem or example.
(c) Explain method of finding sum of the terms of a geometric progression.

Geometry

1. (a) Describe properties of the faces and diagonals of a parallelopiped.
(b) Describe property of obtuse angles of a convex polyhedral vertex.
(c) Problem (supplied at time of examination).

2. (a) Discuss volume of an inclined parallelopiped.
(b) Give theorem concerning three perpendiculars and converse theorem.
(c) Problem.

3. (a) Describe: surfaces of revolution; cylindrical surface; right circular cylinder; lateral and total surfaces of a cylinder.
(b) Describe lemma concerning the similarity of triangles.
(c) Problem.

4. (a) Describe lemma concerning the volume of bodies resulting from the rotation of a triangle.
(b) State property of the bisector of an internal angle of a triangle.
(c) Problem.

5. (a) Discuss volumes of a spherical sector and of a sphere.
(b) Give theorem concerning the intersection of two parallel planes by a third.
(c) Problem.

EDITOR'S NOTE: For more information on Soviet and US education, see:

Soviets Redesign School Curricula, July 27 '59, p 26. Tells of addition of extra grade to seven-year (elementary) school.

Now Hear This: US Education Superior to European, May 19 '58, p 28. Byron S. Hollinshead, former president of Coe College, after returning from five years with UNESCO in Paris, reports Europeans have highest regard for US education system and the results it has produced.

Must We Compete with Moscow in the Education Race? June 30 '58, p 24, gives opinions of five leading educators. They all agree our system should be improved, but that the solution does not lie in mimicking Russia, or any other country, for that matter.

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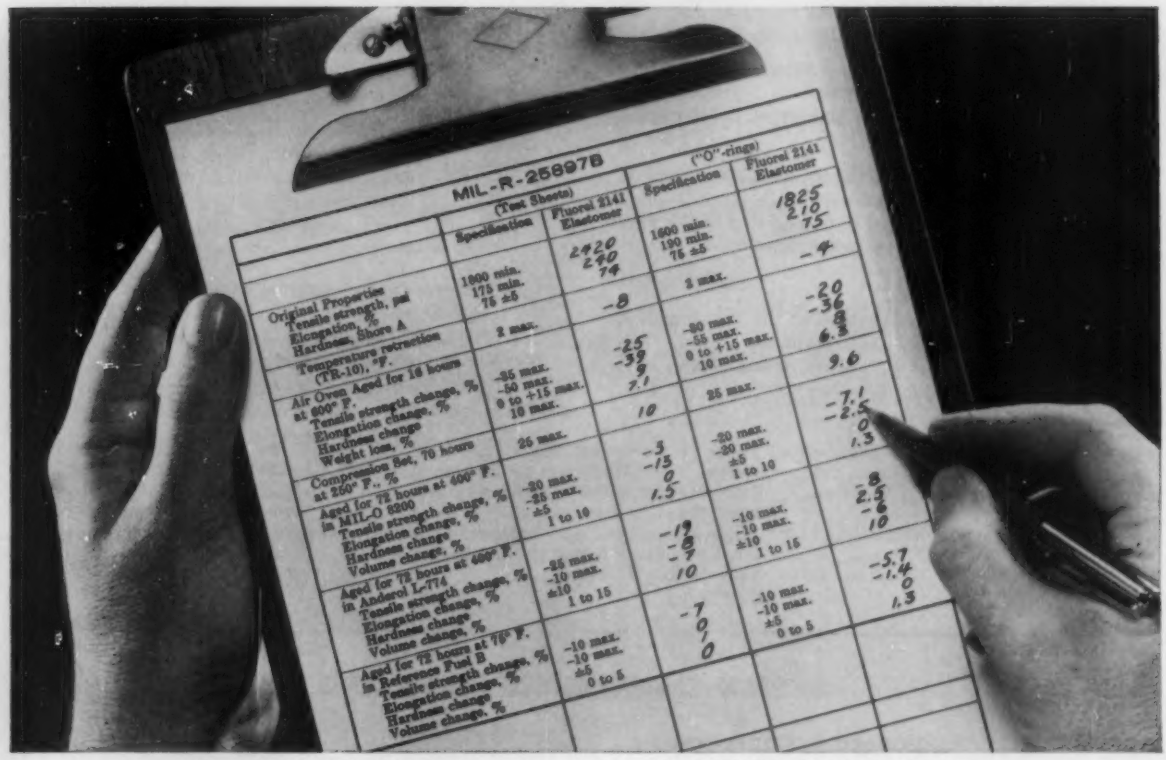

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CHEMICAL DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

for rectangular sections, nomographs find . . .

HELICAL-SPRING STIFFNESS

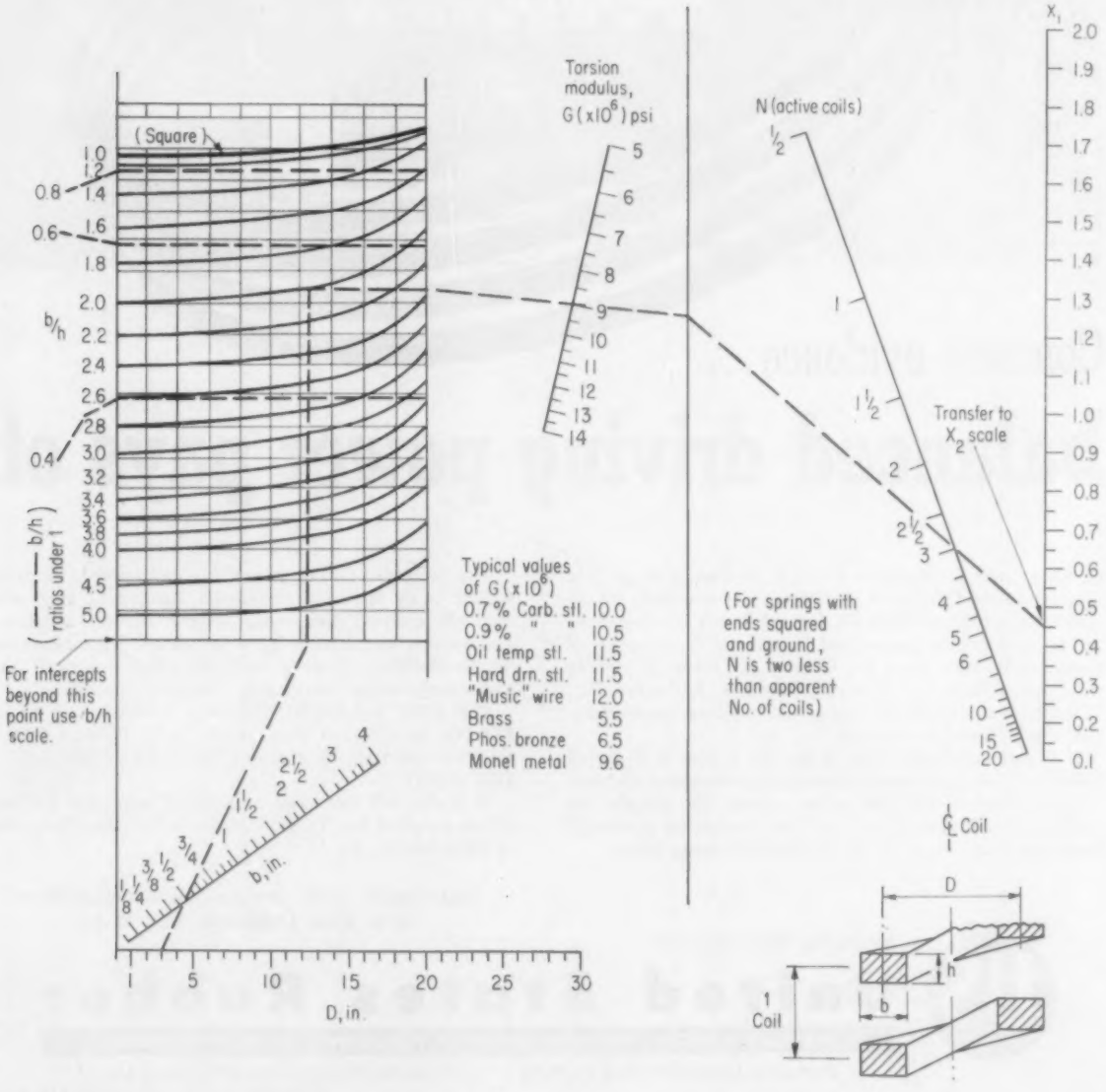
J F WATERS, *Westerham, Kent, England*

Helical springs of rectangular bar are finding increasing work for such duties as safety-valve springs, heavy-vehicle suspensions, couplings. The two nomographs presented here help find needed dimensions.

EXAMPLE: A spring with $b = \frac{1}{2}$ in., $h = \frac{1}{4}$ in. (see sketch) has mean dia $D = 3$ in., and three effective coils. If torsion modulus $G = 9 \times 10^6$, find stiffness and deflection under 150-lb load.

PROCEDURE: Join known quantities by secants to find spring rate (stiffness) = 258 lb per in. deflection. For 150-lb load, deflection will be 150/258 = 0.58 in.

continued on page 63



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Crushing rock for concrete block is, at best, a tough job. Stone dust and flying rock particles create unusually severe operating problems. (Our photographer actually found in-action photographs impractical because of the severity of these conditions.) Says Mr. Charles P. Lower, Jr., works manager of Bethayres Concrete Products, Bethayres, Pa., "The crusher is probably one of the toughest applications that can be found for any belt."

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U. S. Royal V-Belts and engineering assistance for these drives supplied by "U. S." Distributor Lindsay-Oberholzer of Philadelphia, Pa.

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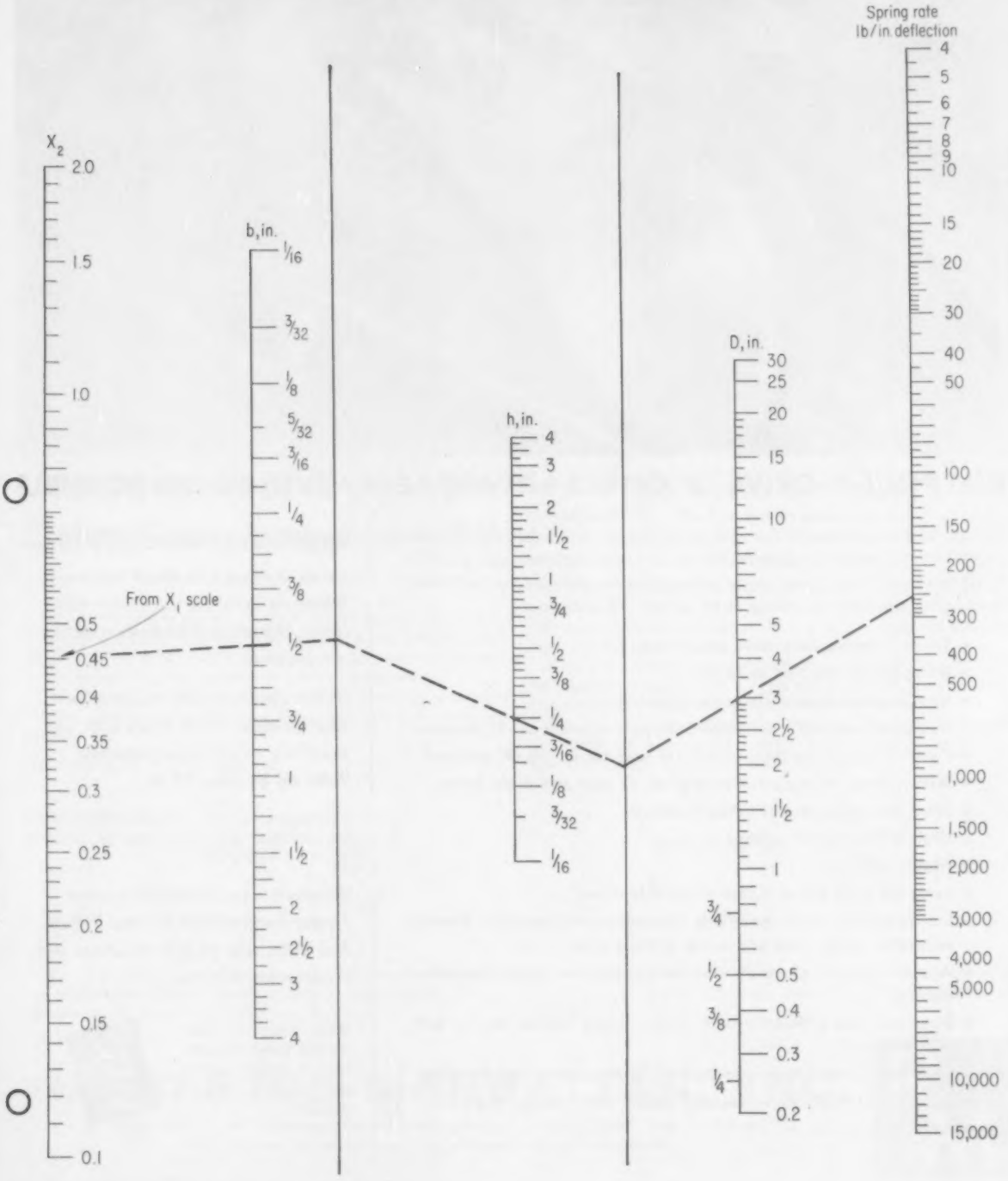
HELICAL-SPRING STIFFNESS continued

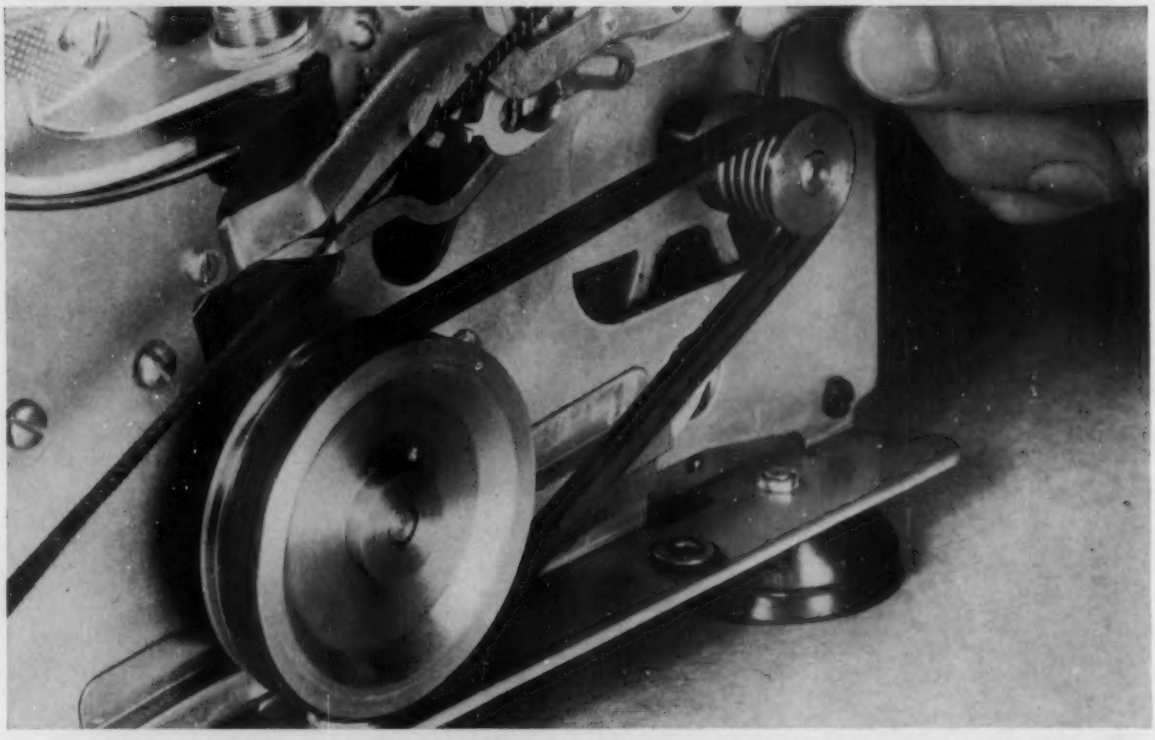
The nomographs are based on the formula

$$\text{Rate} = \frac{G\mu b^2 h^2}{ND^3}$$

where μ is a factor dependent upon values of b/h and D/b. The small chart combined with first nomograph incorporates this factor, which is based on information in British Standard 1726:1951, available here through the American Standards Association.



Designers think of R/M first for asbestos, rubber,



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Design advantages sought for years for small machinery drives are now available exclusively in Poly-V Drive "J"—utilizing a single parallel V-ribbed belt running on space-saving sheaves grooved to mate precisely with the belt ribs. Only R/M Poly-V "J" offers . . .

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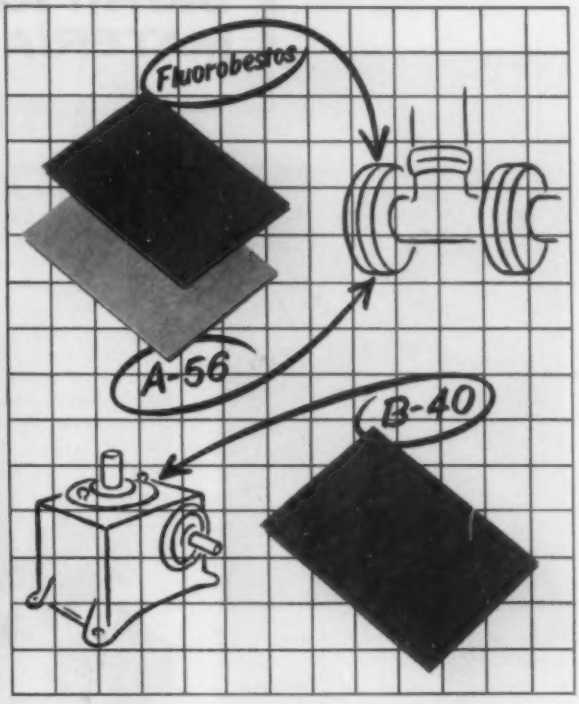

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A-56 . . . for flange temperatures to 1100°F
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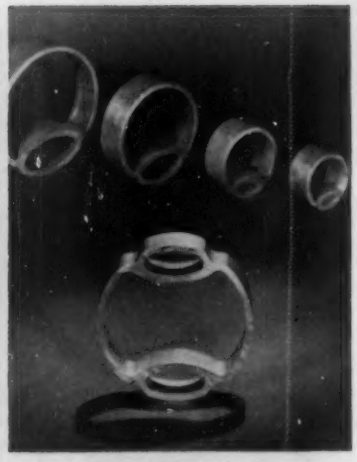
CIRCLE 65 ON READER SERVICE CARD

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Pipe with built-in channels . . . is said to reduce cost of recirculating heating fluids in piping systems. One-piece, extruded pipe contains two integral channels flanking larger, product-carrying pipe area. Heating medium travels through one small oval passageway, maintaining temperature of bulk material in product line. At terminal, fluid is reheated, if necessary, prior to being returned through second channel. Available in 2-, 3- and 4-in. pipe sizes. Can also be used for recirculating refrigerants and for conveying several products in one piping system. **Aluminum Co of America, 1501 Alcoa Bldg, Pittsburgh 19.**

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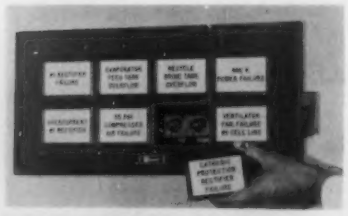
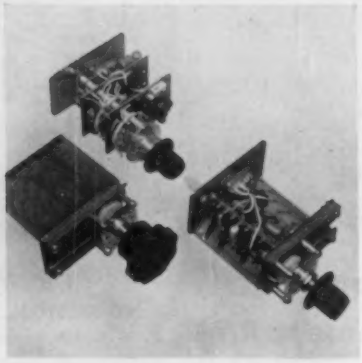


Flexible, modular lamp annunciators . . . and annunciator systems offer plug-in circuits that can be removed and changed for different operation sequences, multiple lamps to insure signal in event of lamp burnout, snap-in indicator plates, sequential circuits, data-logging terminals and snap-fit, one-piece molded lamp compartments. Lamp annunciators are said to detect and indicate, visually and audibly, any abnormal condition or change in status and then actuate control equipment. After signalling, units reset themselves to perform again. Annunciators monitor pressure, temperature, opening of circuit breakers, high or low liquid levels, power equipment failure or any break in electrical circuit. Indicator sizes vary from 1 x 3 in. to 1½ x 2 in. to 2 x 3 in. **Edwards Co Inc, Norwalk, Conn.**

Circle 301 on Reader Service Card



Packaged switching assembly has eccentric or cardiac cam to actuate movable printed circuit board in contact with another stationary circuit board. Variations in cam shape and circuit layout can be used to accomplish complex switching sequences. Unit at lower right, developed for electronic attenuator, simplified associated circuitry of original rotary switch, top, and eliminated approximately 30 component parts. Terminal connections, instead of having to be soldered on many different and relatively inaccessible surfaces, were all concentrated on single, accessible plane. Basic unit, without electronic components, is shown at lower left. Nucleus of semistandardized units is being developed. Custom units can be designed to requirements. Simple circuitry assemblies, in large quantities, are about $5 each. Applicable where more than three alternatives of switching are required. **Ucinite Co, 459 Watertown St, Newtonville, Mass.**

Circle 302 on Reader Service Card

Size 5 stepping motor . . . or indexing device is available with 8, 10, 12, 18, 20 and 24 steps per revolution, in unidirectional or bidirectional models, with or without detent. Mechanical load can be positioned manually in either direction and direct coupling of shaft to load permits mounting of position indicator on shaft. Shaft extensions are available at one or both ends. Stepping rate of motor is 15 to 25 steps per sec, depending on number of positions, load and other factors. Mechanism is enclosed in protective housing, has magnetic anti-overcoast and is permanently lubricated. Models are offered in any duty cycle within operating voltage range of 6 to 350 v dc. Withstands vibration of 10 g, 2000 cps; shock of 100 g, 6 millisec ±1 millisec. Operating temperature range is −67 to 248 F, max coil temperature. Priced about $26 for 1 to 9 units. Most models from stock. **Ledex Inc, 123 Webster St, Dayton 2, Ohio.**

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Vinyl dispersion resin . . . for organosols and plastisols is said to allow formulation of compounds with low viscosity at both low and high shear rates, as well as excellent viscosity stability. **Diamond Alkali Co, 300 Union Commerce Bldg, Cleveland 14.**

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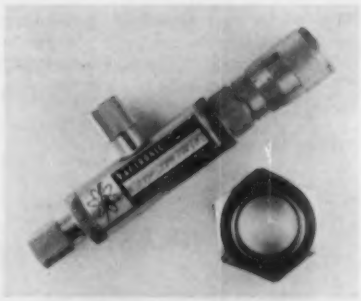


Adjustable leak valve . . . for pressure regulation in high-vacuum region affords micrometer control of leak rates from 0.02 to 2 standards ccs per sec. Special filter protects instrument from dust particles over 5 to 10 microns in size. Measures 5⅜ in. x 1 in. dia. Weighs fraction over 1 lb. Machined brass body is nickel plated. With nylon and Teflon seals and ⅛-in. dia nipples, price is $72.50. **Vactronic Lab Equipment Inc, 21 Monmouth Court, E Northport, NY.**

Circle 305 on Reader Service Card

continued on page 69

Circle 66 for Cylinders→
Circle 212 for Fittings & Hose→

Hannifin high-pressure hydraulic cylinders feature a drip-free rod gland with "LIPSEAL"® and "WIPERSEAL." This feature, plus straight-thread, O-ring-sealed ports, insures leak-proof cylinder installations.

from PARKER-HANNIFIN...

straight-thread ports and fittings for leak-proof hydraulic systems

Such Parker "Triple-lok"® flare-type and "Ferulok"® flareless fittings include straight-thread shapes in steel and stainless steel for leak-free tube connections. Write for our handy "Fittings Finders" for quick selection of Parker tube fittings, hoses and hose fittings.

Parker straight-thread hydraulic fittings, mated with S.A.E. bosses (offered at *no extra charge* on Hannifin cylinders), guarantee leak-proof cylinder port connections.* This use-proved sealing method is J.I.C. recommended.

To insure leak-proof performance throughout your hydraulic systems, Parker offers both "Triple-lok" flare-type and "Ferulok" flareless fittings for leak-proof tube connections. Where you need high pressure, permanent-end hydraulic hose assemblies, Parker supplies "Krimp-lok." And for fast, leak-proof field service or replacement, Parker "Hoze-lok" fittings require no skiving of the hose, need a minimum of tools for assembly.

Your Parker-Hannifin man is qualified to help you with installation problems. He'll also help you plan your hydraulic layouts.

**Both Parker fittings and Hannifin cylinders are still available with "dry-seal" pipe threads.*

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois

EC-1357 cuts costs, makes possible stronger sandwich panels

LABORATORY TESTS show EC-1357 provides the high strength and rigidity called for in nonload-bearing sandwich structures.

3M Adhesive EC-1357 bonds all kinds of skin and core materials *without heat.* You'll speed production, cut costs, build in high strength for non-load-bearing sandwich panels.

You can force-dry the solvent out of the adhesive prior to bonding. And a nip roller or cold press is all that is required to complete the bond.

EC-1357 provides maximum immediate strength. And the bond continues to strengthen as it cures at room temperatures.

Dark in color, EC-1357 absorbs infrared heat quickly, dries fast; so no production delay is necessary. And it sprays on with minimum cobwebbing, thus saving materials.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU!

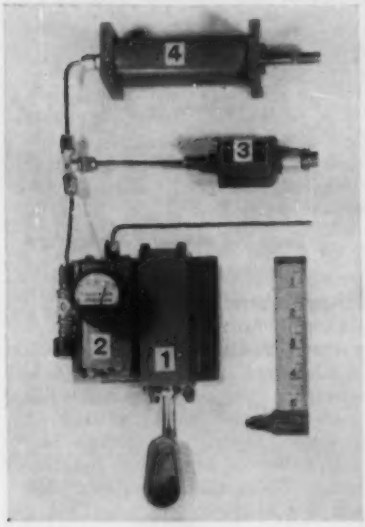
Consult 3M Research. Contact your 3M Field Engineer. Or, for information and free literature, write: A.C.&S. Division, 3M, Dept. SBS-40, St. Paul 6, Minnesota.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



Nonelectric safety control . . .

system is sensitive to wide range of temperatures, pressures or both in combination. When small captive charge of compressed air is dumped to atmosphere by pressure- or temperature-sensing devices, system actuates most types of pilot-operated valve, switch, warning or other control. Can sense pressure up to 2000 psi. Aluminum and brass construction eliminates fire hazards. Resets after operation or shutdown, and set points are adjustable. Shown is small diesel engine installation. Basic elements are 1) hand charging unit, 2) pressure-sensing valve with charge air gage, 3) temperature-sensing valve, 4) actuating units. System is particularly suited to all kinds of unattended machinery. **California Controls Co, Dept 179, 1525 Powell St, Oakland 8, Calif.**

Circle 306 on Reader Service Card

Nylon castings up to 6 lb . . .

are made practical by fractional tooling costs, lower running rates and short-run requirements of licensed European process. Utilizes higher viscosity nylon than can otherwise be used. Reported to present no limitation on cast-in inserts, threads, lugs, intricate shapes or varying thicknesses. **Nylon Molded Products Corp, Dept R-280, Garrettville, Ohio.**

Circle 307 on Reader Service Card

Switching galvanometer . . .

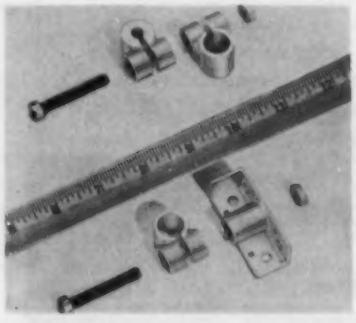
offers sensitivity as low as 1 microamp, full scale. Functions in control systems where energizing signal is too slight to energize conventional relays. Friction-free movement requires less torque to perform signaling operation. In systems employing contacts, less closing pressure is needed to energize controlled circuit. Utilizes taut-band meter movement. Pointer of taut-band meter carries moving contact that consists of small permanent magnet with closely controlled field and small gold electrical contacts. Torque elements can be adjusted to control switching value. Since movement of indicator pointer is controlled by magnets in permanent contact, it is impossible to have slow-contact closing. Switching galvanometer energizes auxiliary relay rated at 50 w and can directly control magnetic switch. **Hickok Electrical Instrument Co, Dept 122, 10514 Dupont Ave, Cleveland 8.**

Circle 308 on Reader Service Card

Color-coated stainless steel . . .

in shades of brown and black are now on the market, with colors such as blue, green, red and gray in the process of being field-tested. Color is achieved by application of chromate-base coating similar to that used on inner lining of metal containers. Coating is applied by spraying, brushing or rolling and then is cured at about 350 F. Process is said to be simpler and more economical than previously announced methods for making black or gray coated stainless. Reported to have uniformity of color, good surface adherence and abrasion resistance. **Allegheny Ludlum Steel Corp, River Rd, Brackenridge, Penna.**

Circle 309 on Reader Service Card



Rod, tube and pipe assemblers

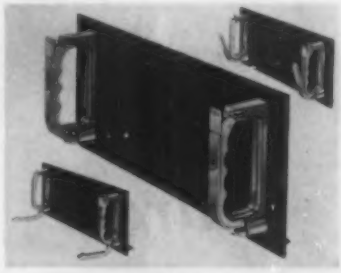
are die-cast zinc units that grip all around tubes or piping instead of only at the tip of fastening screw. Grip is reported not to burr, score or distort. Toothed faces of paired fittings form rigid joints at any 10° increment. Since fastening nut rests in unit, tightening screw sets all-around grip at the same time that it locks joint at desired angle. Screw and nut are concealed in fitting recess. Variety of units are available for various sizes, for mounting on metal or wood bases, for mounting microswitches and other devices and for use with electrical BX. Sample kit is available to manufacturers. **Rotocon Div of Unistrut Products Co, 933 W Washington Blvd, Chicago 7.**

Circle 310 on Reader Service Card

Microminiature rivets . . .

are available in over 40 standard sizes in lengths varying by $\frac{1}{32}$-in. increments. Made from nonmagnetic brass with 24-kt gold electroplated and shot burnished finish. Head form is modified brazier with low contour and min functional diameter for stresses imposed. Suitable for electronic and instrument applications. Cost of fasteners vary from 2 to 8¢ contingent on size and quantity. All sizes from stock. **Circon Component Corp, Santa Barbara Municipal Airport, Goleta, Calif.**

Circle 311 on Reader Service Card



Double safety latch . . .

for locking electronic cabinet drawers has leverage action to inject and reject drawer through final ½ in. of travel. Requires finger release of safety lock before drawer can be opened with handle, preventing accidental opening. Housing is shaped to fit contours of hand and can be used to carry drawer. Conforms to MIL-E-5400C for gloved-hand operation. Available in various finishes. **Hartwell Co, 9035 Venice Blvd, Los Angeles 34.**

Circle 312 on Reader Service Card

Miniature low-level amplifiers

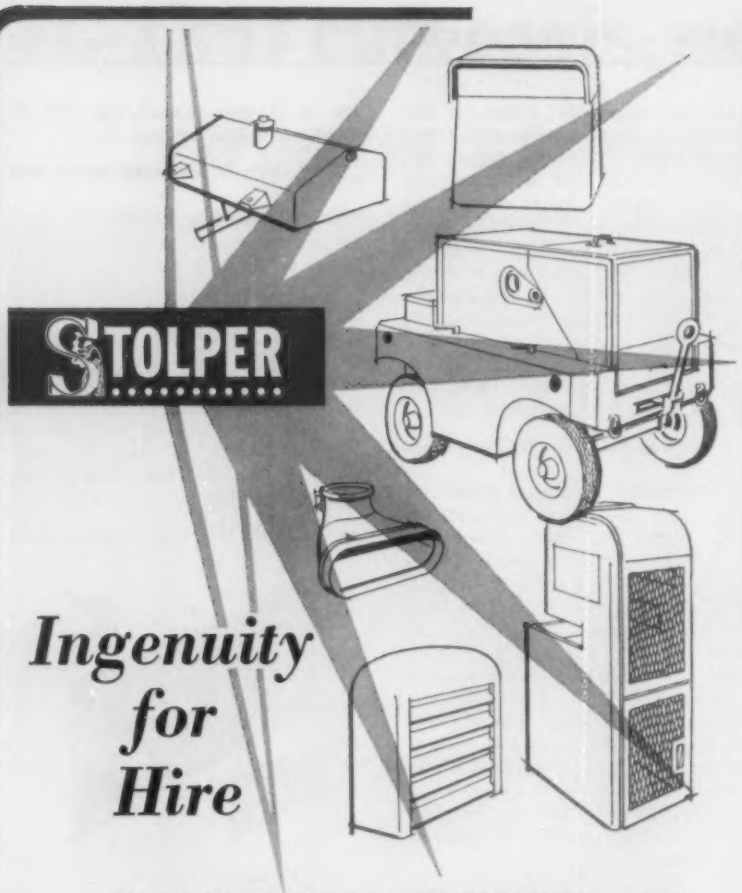
accept input signals in the milliv range and produce output signals ranging from 0 to 5 v dc. One model operates on 115 v dc, 400 cps power; the other on 28 v dc power. Both are suited for temperature and strain measurements. All components are completely encapsulated. Delivery, 4 to 6 wk. **Magnetic Research Corp, 3160 W El Segundo Blvd, Hawthorne, Calif.**

Circle 313 on Reader Service Card

Laminated mica insulation . . .

is reported to have dielectric strength of 1400 vpm, greater than any known mica insulation. Consists of silicone-bonded

continued on page 70



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It's sheet metal wizardry — the things Stolper can do with sheet steel, aluminum or stainless. Skilled engineers directing expert craftsmen operating modern machines will add extra value to your sheet metal parts, sub-assemblies or assemblies. A discussion of your specific project costs nothing. Test our ingenuity soon.

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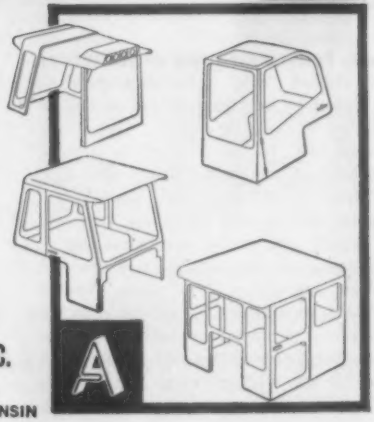
MENOMONEE FALLS (Milwaukee District), WISCONSIN

make a tough job easy

Ask Allen to design, engineer and build a cab *to match your machine.* Diversified experience assures maximum safety, smart styling, effortless visibility and operator convenience at reasonable cost. Ask for more details — no obligation.



ALLEN INDUSTRIAL PRODUCTS, INC.
Affiliate of Stolper Steel Products Corporation
306 Pilgrim Road
MENOMONEE FALLS (Milwaukee District), WISCONSIN

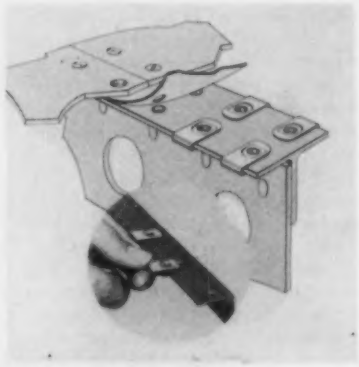
mica mat sandwiched between layers of silicone-varnished glass cloth. Designed for Class F and H applications. Expected to be used primarily as slot insulation for random-wound ac armature coils, as phase insulation in ac motors and as layer insulation in transformers. Available in thicknesses of 8, 10, 12, 15, 20 and 25 mil. Reported to be compatible with all good impregnating varnishes. **General Electric Co, Schenectady 5.**

Circle 314 on Reader Service Card

Self-protected ac motors . . .

include 67 different types of UL-approved open motors in various voltages, speeds and mountings. Protection against high temperatures and current overload is factory-assembled and completely wired inside motor. Motors in ¼- through 3-hp ratings, are suited for all three-phase applications. **Kingston-Conley Inc, 900 North Ave, Plainfield, NJ.**

Circle 315 on Reader Service Card



Self-locking clip-on nut . . .

can replace standard nutplate and eliminate riveting. Applied where suitable edge margin exists or through cutout hole in center of panel, clip-on nut slips onto panel or structure and locks firmly in bolt hole. Available for thicknesses of 0.020 to 0.150 in. Meets MIL-N-25027—120,000 psi class. **Monadnock Mills, Sub of United-Carr Fastener Corp, San Leandro, Calif.**

Circle 316 on Reader Service Card

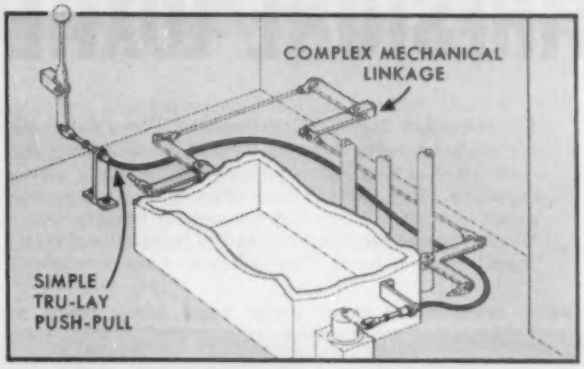
Vibration-monitoring valve . . .

is used as two- or three-way unit for pneumatic or hydraulic control systems to 80 psi. Adaptable to engines, compressors, fans, motors and other rotating or reciprocating equipment. Sensitivity of snap-action, nonoverlap valve is manually adjustable. Sensitive to vibration from any direction in plane perpendicular to its longitudinal axis. Internal cylinder in

continued on page 74

TRU-LAY *PUSH*-PULL CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

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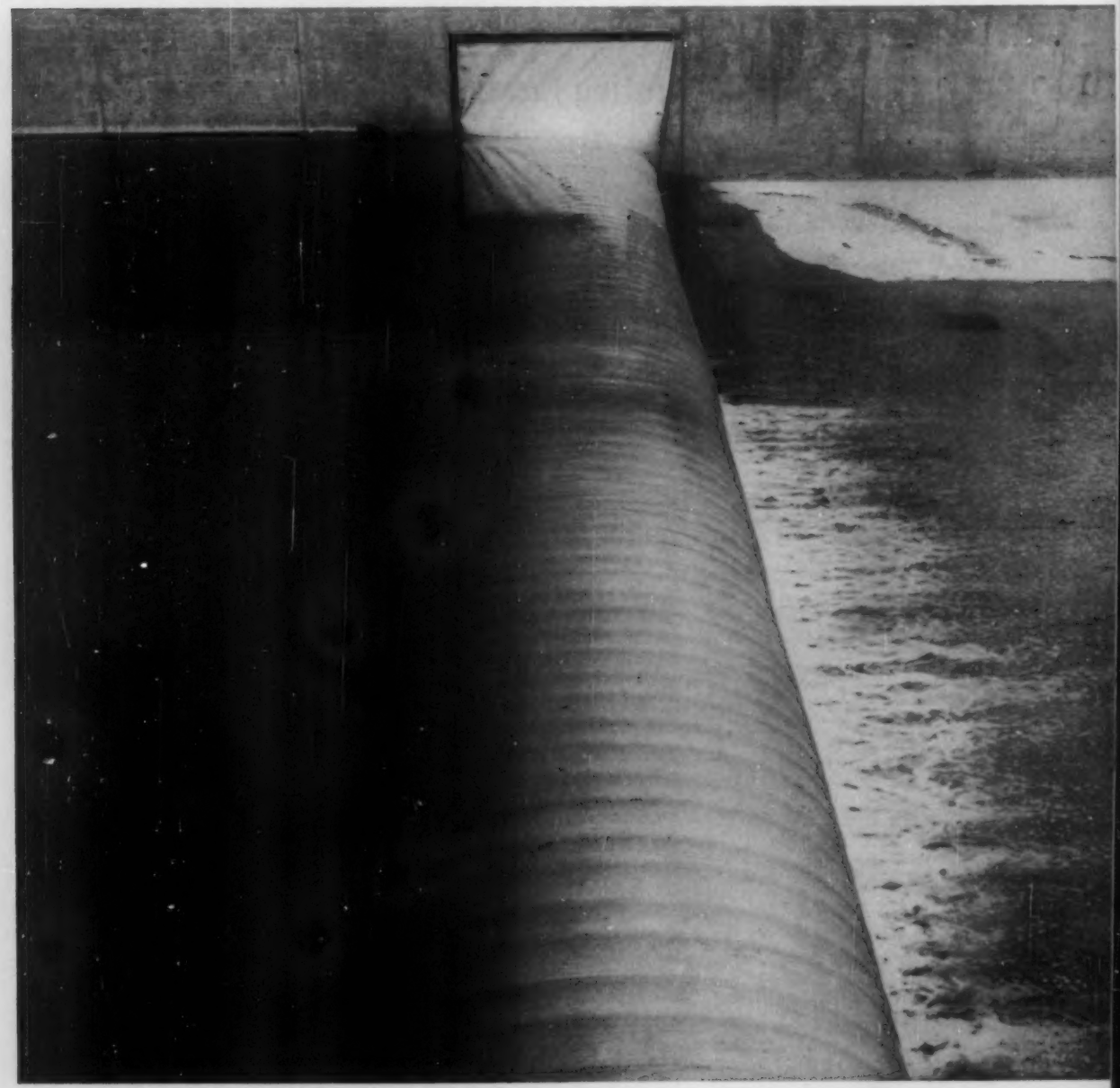
6800-E East Acco Street, Los Angeles 22 • 929-E Connecticut Ave., Bridgeport 2, Conn.

ACCO

FIRESTONE LOXITE ADHESIVE HELPS

For years, Los Angeles' Department of Water & Power maintained wooden dams in the Los Angeles River to conserve vital rain and river water. These dams were expensive, since every winter either they were swept away, or had to be torn down to protect the area from floods. More of the lost water had to be saved and high annual costs reduced. The solution is the enormous 3-ton fabric dam pictured below. It was built by Firestone of neoprene-coated 2-ply nylon in five sections permanently joined together by an outstanding fabric-to-rubber bonding agent—Firestone Loxite Adhesive 6060. Through its lasting cohesion, flexibility and resistance to deteriorating influences, this Loxite Adhesive helps permit the dam to be collapsed at will whenever



FABRIC DAM HOLD BACK A RIVER!

flood danger arises and re-inflated (with 50,000 gallons of water) in less than half an hour. It's another example of how the remarkable family of Firestone Loxite Adhesives is helping to speed development of new assembly and fastening concepts. And whatever the service conditions of your product demand in adhesives, whatever production and cost problems you may be encountering, there is a Loxite compound that can be tailored to your individual needs. We cordially invite you to mail your detailed requirements on the form below for study and recommendations by Firestone Technical Service engineers. You are placed under no obligation whatsoever. There is also a comprehensive new Loxite Adhesives brochure now available. It's yours for the asking.

15-1

Gentlemen:
We would like to have your suggestions on adapting Loxite Adhesive to our application. Complete information is specified below. It is understood that this information will be kept confidential and that our company will be under no obligation at all.

HERE IS A DESCRIPTION OF OUR ASSEMBLY PROBLEM. PLEASE MAKE RECOMMENDATIONS FOR A SUITABLE BONDING COMPOUND.

MATERIALS TO BE BONDED_____ **TO**_____

DESCRIPTION AND END USE OF FINISHED ASSEMBLY_____

PRESENT METHOD OF JOINING_____

DIFFICULTIES ENCOUNTERED WITH PRESENT METHOD_____

MECHANICAL STRESSES TO WHICH ASSEMBLY WILL BE SUBJECTED_____

TEMPERATURE EXTREMES_____ **TO**_____

VIBRATION PROBLEMS_____

SOLVENTS TO WHICH ASSEMBLY MIGHT BE EXPOSED_____

COMPANY_____

STREET ADDRESS_____

CITY_____ **ZONE** **STATE**_____

SIGNATURE_____

Mail to:

Firestone Tire & Rubber Co.
Application Engineering Laboratories
Xylos Rubber Division
1200 Firestone Parkway
Akron 17, Ohio

Firestone

XYLOS RUBBER COMPANY, AKRON 1, OHIO

A division of The Firestone Tire & Rubber Company

Design Uniform lift into equipment with DUFF-NORTON WORM GEAR JACKS

Many designers find a ready answer to precise control of linear motion in machinery or equipment with built-in Duff-Norton Worm Gear Jacks.

They are used singly, in tandem and in multiple jacking arrangements to position loads weighing from a few hundred pounds to as much as several hundred tons.

When connected in tandem or groups of four, six or more, these jacks always raise or lower in exact unison regardless of load distribution. They are also used for application of pressure, to push or pull and as linear actuators.

Duff-Norton Worm Gear Jacks are self-locking and will hold heavy loads in position indefinitely without any creep. Since there is no fluid or air to leak, the action is always positive and maintenance is no problem.

These jacks are available in eight standard models with capacities ranging from 2 to 100 tons and with standard raises from 6 to 24 inches. Special raises can also be furnished.

To learn more about how Duff-Norton Worm Gear Jacks may be used in your equipment, send for the bulletin which shows engineering drawings of jacks, Duff-Norton Mitre Gear Boxes and typical applications. Ask for AD-66DD.

DUFF-NORTON COMPANY

P. O. Box 1889 • Pittsburgh 30, Pennsylvania

COFFING HOIST DIVISION • Danville, Illinois

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

COFFING HOISTS
Ratchet Lever • Air
Hand Chain • Electric

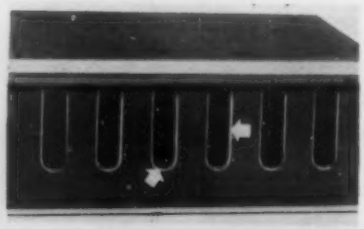
standard unit resets tripping mechanism, with application of 40 to 80 psi. Reset cylinder can also be used in time-delay circuit to prevent tripping of valve on high-amplitude vibrations during startup. **Amot Controls Corp, First St and Nevin Ave, PO Box 1707, Richmond, Calif.**

Circle 317 on Reader Service Card

Bimetal input regulator . . .

controls electrical inputs to heating element or similar device. It is about the size of a five-heat rotary switch. Controls resistive loads to 15 amp. Suitable for use with electrical equipment, commercial devices and home appliances. **Indiana Div, Robertshaw-Fulton Controls Co, PO Box 129, Indiana, Penna.**

Circle 318 on Reader Service Card



Rounded edges on wire slots

are now standard on inside and outside surfaces of open-slot electrical wiring duct from this manufacturer. Protect insulation on wires during and after installation. Duct is made from nonflammable plastic and does not support fungus growth. Available in 16 standard sizes ranging from 1 x 1 in. to 4 x 3 in., in 5- or 6-ft lengths. Offered in white, black, dark gray or light gray. **Panduit Corp, Dept PE-1, 14461 Waverly Ave, Midlothian, Ill.**

Circle 319 on Reader Service Card

4000-w gas-engine generator

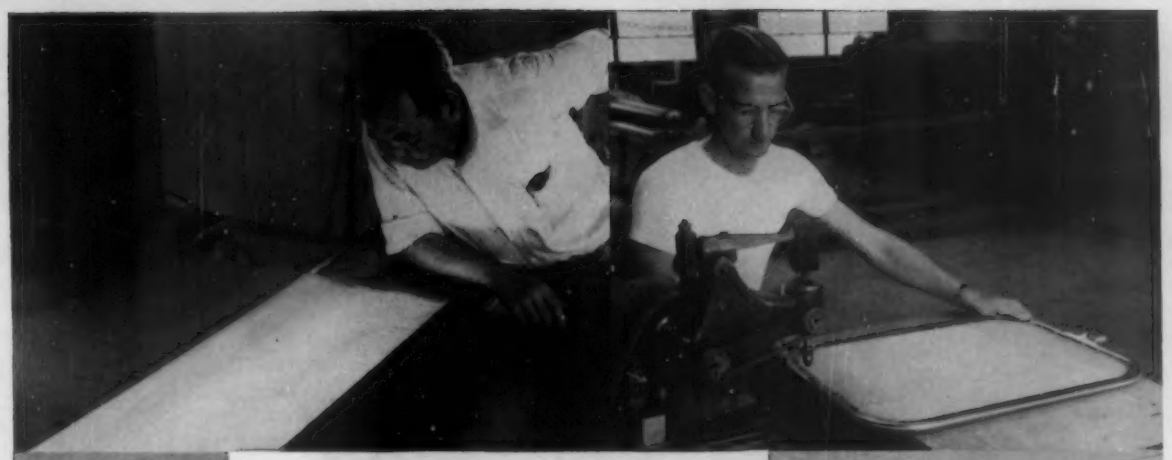
will start and power 3 hp motor under full rated load; or safely carry 4000-w load of lights on single 115- or 230-v circuit; or carry many typical standby loads beyond capacity of conventional 3500- or 4000-w generators. Idling control, included as standard equipment, is said to save up to 60% in fuel. Available in electric, manual or remote-starting models. **Wincharger Corp, Sub of Zenith Radio Corp, Sioux City 2, Iowa.**

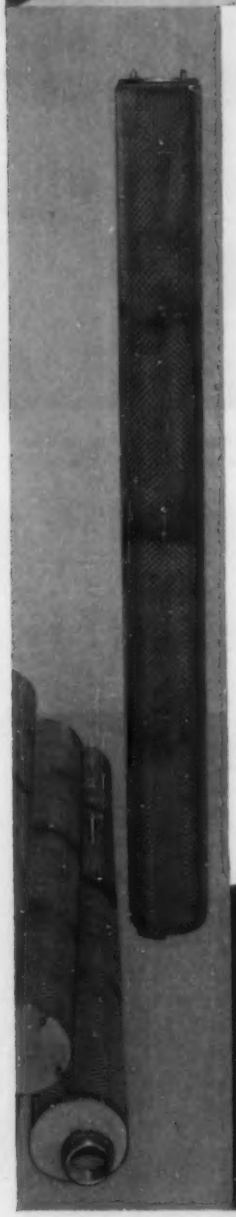
Circle 320 on Reader Service Card

Angular position transducers

provides continuous, accurate measurement of angular displacement. Internal element is high-strength metal beam, onto which are bonded strain gages that are electrically connected to form balanced

continued on page 78





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that's why you automatically get service with your order . . . whether you need dozens of midget strainers or a single giant-sized retaining screen.

Careful, competent workmanship and constant inspection assure you of quality . . . modern machinery and accurate scheduling assure you of prompt delivery. And, a Cambridge Field Engineer follows up your order to make sure our product is giving you the best possible service. Let us quote on your next order for wire cloth fabrications. We manufacture wire cloth from any metal or alloy—including titanium—in nine basic weaves. We'll work from your prints or draw up prints for your approval. Call your Cambridge Field Engineer . . . he's listed in the yellow pages under "Wire Cloth". Or, write for FREE 94-PAGE CATALOG.

The Cambridge Wire Cloth Co.

Department P • Cambridge 4, Md.

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

Bearings in the making are these lengths of Pittsburgh seamless mechanical tubing in the charging rack of a high-speed automatic cutting machine at the plant of a leading bearing manufacturer. Special machining, hardening properties are built into tubes for this customer who produces more than 6,000 inner-rings per day.

Leading Bearing Maker Finds . . .

Machinability of Pittsburgh Steel's Tubes Lengthens Tool Life, Gives More Pieces

One of the nation's oldest and largest ball bearing makers used alloy bars for high-speed machining of a difficult bearing part for 20 years.

But when Pittsburgh Steel Company showed how low-carbon steel tubes could provide the machining and case-hardening properties required, this big-name manufacturer switched to Pittsburgh seamless mechanical tubing.

These were the clinchers:

- **More pieces per day**
- **Longer tool life**
- **Less machining and scrap**
- **Lower cost material**

The part involved was the inner-ring of a clutch throw-out bearing—a heavy production item at this customer's biggest plant since 1937. The bearing is the part that takes the abuse from the spinning clutch pressure-plate when you step on the clutch pedal.

To produce the inner-ring from low carbon steel, the customer demanded seamless tubing that was:

Highly machinable and uniform—for charging into a battery of 8-spindle automatic screw machines which subject each piece to 16 cutting operations.

Exceptionally hardenable and fine grained—for heat-treating to the hardness demanded of bearing steel and for finishing to ultra-close tolerance and super-fine surface.

The customer specified the grade of steel he needed to obtain these properties—AISI C-1024—then asked Pittsburgh Steel's sales engineers to produce it in seamless mechanical tubing.

The bearing maker's automatic machines produce 6,000 to 6,500 bearing inner-rings a day, testing the tubing's machinability with cutting tolerances as little as .003 inch.

Its hardening properties are

proven in a 21½-hour carburizing-hardening-temper cycle.

Structural characteristics meet the test in an integrated finishing-assembly operation that includes grinding and honing, and two 100 percent test operations.

The bearing maker's superintendent of primary operations sums up the advantages of Pittsburgh Steel's mechanical tubing this way:

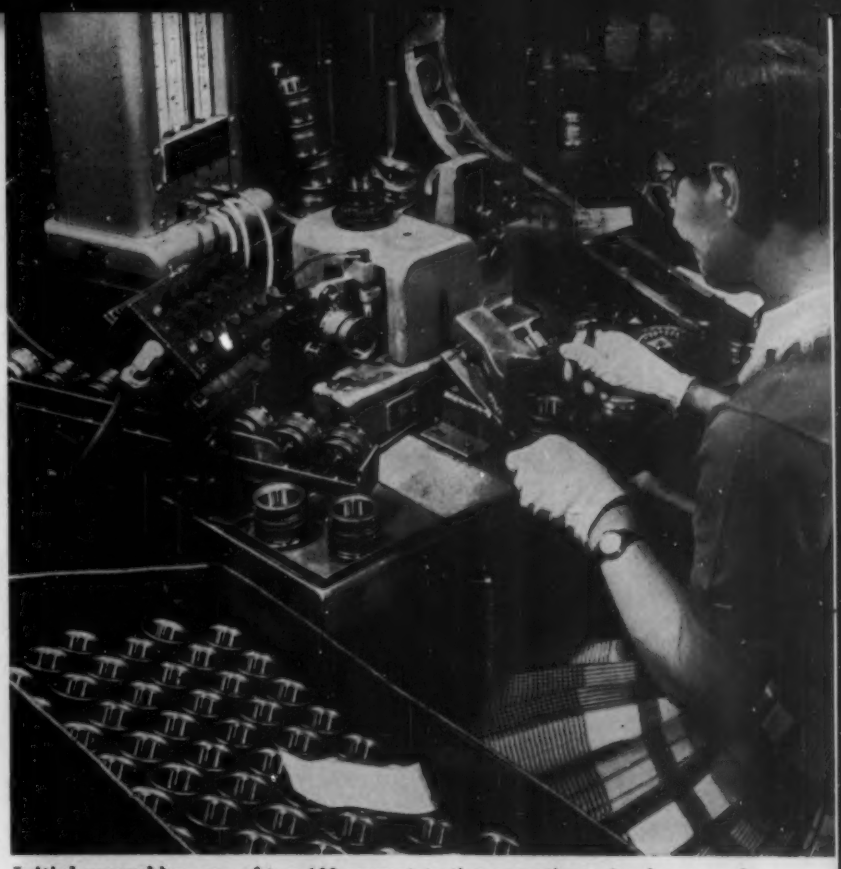
"We get more pieces during a day's operation. And we don't have as many chips to pull.

"We can use a boring tool and this stays in service longer than the drill needed for bar stock. Other tools used for ID cuts also stay in longer. So there we have lower tool costs.

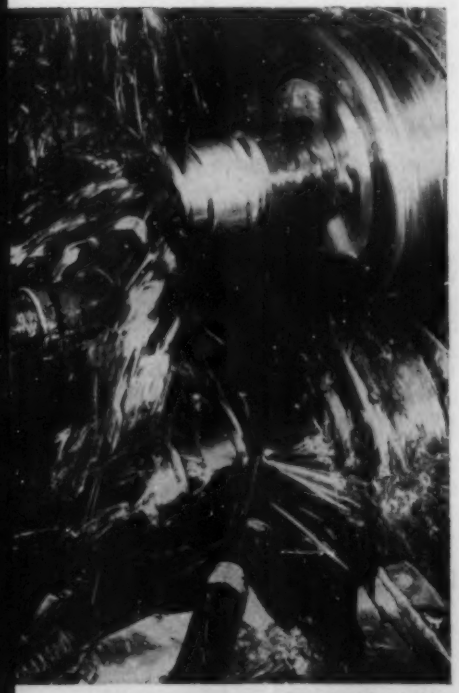
"Finally, we are using a less expensive steel and gaining cycle speed. Since the inside drill speed is the controlling factor on cycle speed for bar stock, the elimination of this operation and the substitution of a boring tool permits cycle speeds of 25 seconds for tubing compared with 28 seconds for alloy bar stock or a little over 10 percent reduction."

This customer's experience with Pittsburgh Steel's seamless tubing—the advantages, the quality, the results—is typical of Pittsburgh Steel's ability to supply tubular products for special applications and of its ability to help customers obtain more profitable production.

These same benefits can be tailored to the needs of your operation requiring seamless mechanical tubing or any of the other tubular products made by the skilled tubemakers at Pittsburgh Steel Company.



Initial assembly—one of two 100 percent testing operations—is where seamless shows its merits in finished bearing.



Tubing proves its machinability here where it takes 16 boring, reaming, grooving, recessing and burnishing cuts.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond, McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

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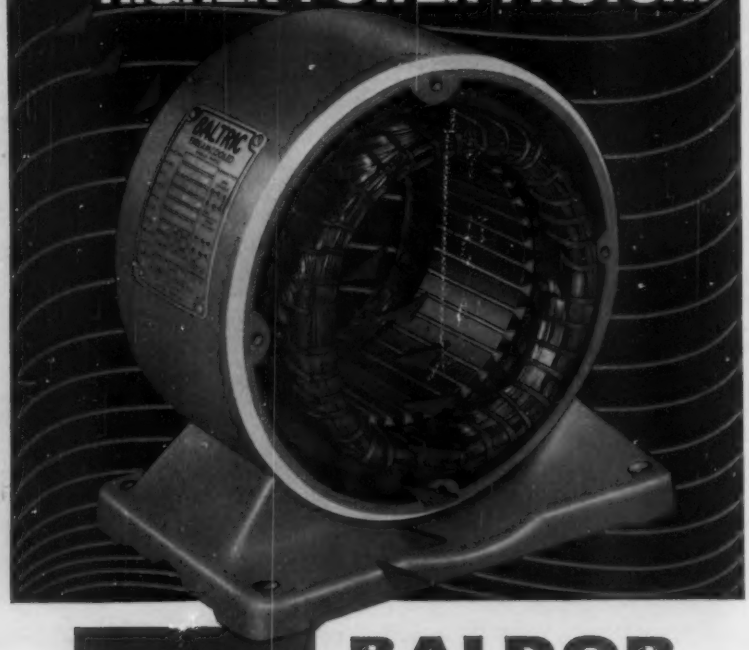
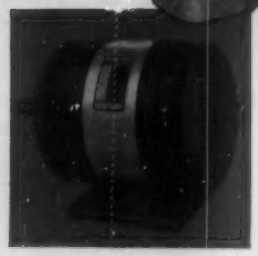
CIRCLE 77 ON READER SERVICE CARD

MORE POWER...
GREATER EFFICIENCY...
HIGHER POWER FACTOR!





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Streamcooled
MOTORS

For general use or for specific applications demanding the most exacting requirements, the Baltric line of motors more than fills the bill. One reason is the "Monocast" Stator shown above.

Steel laminations in an aluminum alloy casting form a stator frame of greater stability . . . greater rigidity. This permits the use of a new and better slot design. The result is uniform magnetic flux distribution throughout the motor—gives more power, greater efficiency, higher power factor and quieter operation.

If you're interested in getting top efficiency from your equipment while holding costs to a minimum, investigate the Baltric line of motors—without obligation! Just write . . .

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Wheatstone bridge. Constant voltage is applied across opposite corners of bridge so that change in angular displacement of transducer input shaft changes resistance of gages and produces change in output voltage. Change in output voltage is measured by indicator or recorder that can be calibrated in angular units. Transducers are available in three standard capacities, offering ranges of ±30°, ±20°, and ±60°. All can operate on ac or dc and have internal stops to prevent overload dampage. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 Fourth Ave, Waltham 54, Mass.**

Circle 321 on Reader Service Card

Vane axial blower . . .

operates on 115 v ac, 60 cps, and delivers 220 cfm of air at 1.75 in. water static pressure; ¾ cfm at 0 in. back pressure. Max current at free air delivery is 1.8 amp; speed is 8000 rpm. Housing is cast, black anodized aluminum, designed to meet MIL specs. Blower measures 4¾ in. dia and 6⅜ in. long. Weighs about 4½ lb. Can also be operated on dc power since universal motor is used. **Globe Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 322 on Reader Service Card

Synthetic rubber-base adhesive

cements highly plasticized vinyls to many other materials that resist oil, gasoline, water, heat and cold, and migration of oils and plasticizers from adjacent materials. Particularly suited for bonding vinyls to metals, woods, cloth and leather. Nonporous surfaces are bonded by allowing complete dry-out of adhesive, followed by reactivation of adhesive. Amber-colored, oil-resistant adhesive has medium-syrup viscosity. Available in 1 qt and 1-, 5- and 55-gal containers. **Schwartz Chemical Co Inc, 50-01 Second St, Long Island City 1, NY.**

Circle 323 on Reader Service Card

Hydraulic gearpumps . . .

permit pressure from outlet port to be diverted behind rear bearings to reduce clearance between bearing faces and gears for optimum volumetric efficiency at all speeds and pressures. Pumps use special

continued on page 82

(Advertisement)

R B & W FASTENER BRIEFS

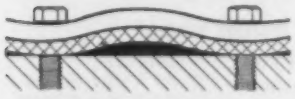
RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By Fred E. Graves

Fastening of gasketed joints

The right fastener for a "flexible" joint rests on type of gasket material and its compressibility. Total preload on all the fasteners in the connection must be enough only to compress the gasket and provide sufficient additional clamping force to withstand the hydrostatic test pressure. More than this brings on a good chance of leakage, through "bowing" of the clamping plate.



Exaggerated sketch showing how too much torque tends to distort clamping plate and leads to leakage.

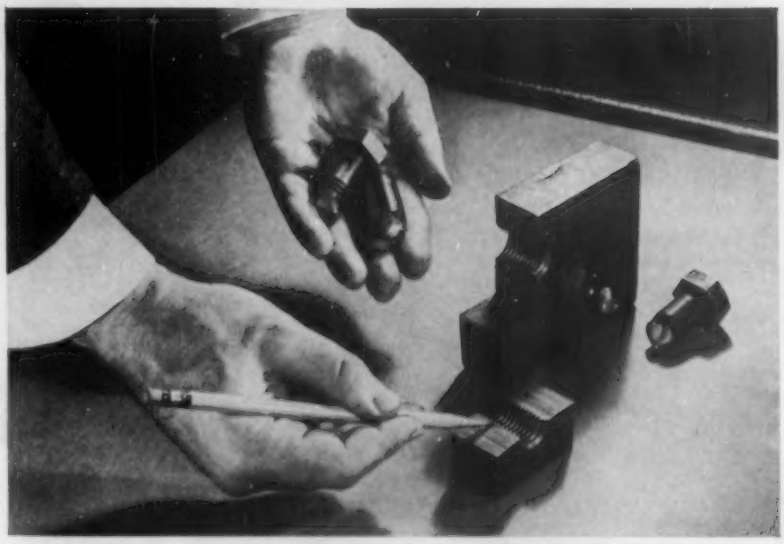
HYPOTHETICAL CASE

Suppose a joint is tightened with Grade 5 Hex Screws to their yield strength, and leakage develops. By going to alloy screws and tightening still further you would still get leakage. But Grade 2 Hex Screws, all torqued evenly, would no doubt solve it.

ACTUAL CASE

The fasteners on one product's flange had to withstand a 4000 pound hydrostatic pressure. But the hard asbestos gasket used took a bolt load of 28,000 pounds for sufficient compression to seal. By substituting a rubber and fibre gasket in this case, bolt load could be reduced. So could bolt size, thereby saving 73% on fasteners.

Using Hex Screws in tapped holes saves money



In the cast "coupon" shown above, the hex screws were torqued tight and removed 50 times—then torqued to failure. Note in the cutaway that the casting's threads are still perfect with no sign of stripping. It was the screws which broke—a clear demonstration that castings fastened with hex screws will suffer no thread damage during repeated disassemblies.

TWOFOLD BENEFIT

When there are no space clearance problems or other special requirements, using studs of 1-inch diameter or smaller often penalizes the user. First, in direct costs, since the more economical hex head screws will do the job to specification. And second, in production costs, since studs require that tapped holes have an *interference* thread fit, which in turn results in slow, "selective" assembly to determine properly mated threads. Hex screws need only a *clearance* fit, assemble faster.

ACTUAL EXAMPLE

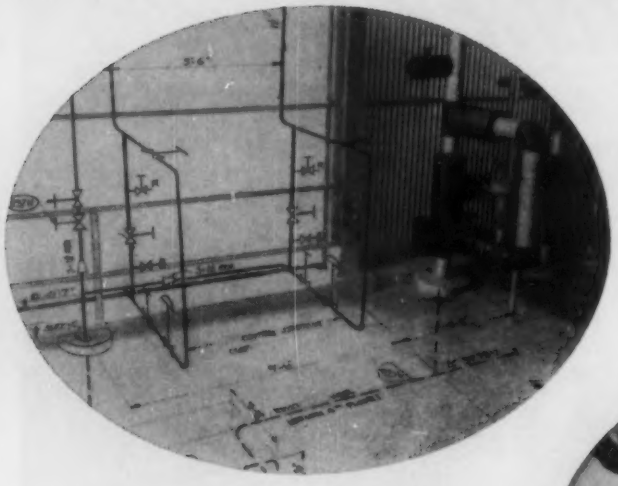
In one of his surveys of fastenings used by one company, the RB&W engineer pointed out that over 250 stud fastenings were being used in a large refrigeration unit. The same number of hex screws, costing $8.45, saved $22 over the studs and nuts. Annually, the total would be $7,800 on the production run of this unit.

Not to be overlooked either was the tangible saving on the less critical tapping job required.

RB&W offers its help on your specific fastener problems, or an overall survey of your fastener usage. Contact Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

CRONAFLEX®: best engineering films you can use



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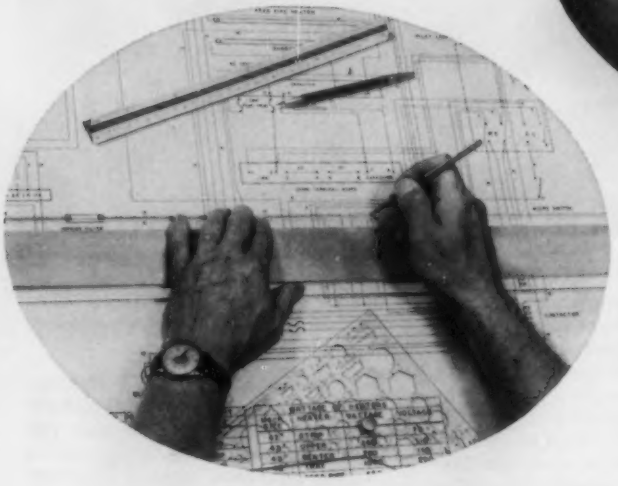
CRONAFLEX copies are free of kinks and tears. Its rugged and flexible base adds years of life to your drawings.



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ALL CRONAFLEX films are on rugged CRONAR* polyester base. This means they are dimensionally stable . . . so stable that many companies use them for exacting template work. CRONAFLEX intermediates provide faster print-through speeds and better resolution of detail because of the optical clarity of the base.

CRONAFLEX films are now available in four types: (1) Direct Positive Film; (2) Contact Film; (3) Projection Film; (4) CRONAFLEX Drafting Films. It's the most complete versatile line of engineering reproduction films you can use. For more information, contact your Du Pont Technical Representative, or write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.

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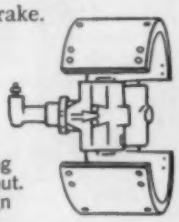
* Du Pont's trademark for its polyester photographic film base.

ACTUAL TESTS PROVE:

NEW STOPMASTER BRAKE IS the most advanced brake design in 30 years!

Over three years of thorough and demanding road tests have proven the superiority of the new Rockwell-Standard Stopmaster Brake. Of its many new improvements the Stopmaster incorporates these major advantages to meet the modern trucking industry's demand for a more efficient, more dependable brake.

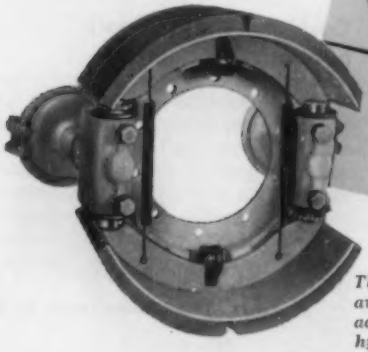


New Stopmaster actuation principal results in higher braking efficiency with less input. In dual actuation design both shoes do an equal amount of work over the entire lining surface. This balanced shoe action assures more dependable service; faster, surer stops; less maintenance.

New Stopmaster 15" diameter permits increased air circulation between brake drum and wheel rim. This results in cooler operating temperatures . . . less heat fade, longer lining life, longer drum life. Smaller diameter means less weight.

AVERAGE RESULTS OF NUMEROUS HIGHWAY VEHICLE TESTS PROVE:

35% lighter weight..	more payload capacity!
38% less heat fade..	safer, more continuous operation!
57% less air volume required..	permits smaller air reservoir tanks!
56% longer lining life..	lower operating cost, less maintenance!
56% longer drum life..	more dependability, less downtime!
66% less adjustment required..	greater safety, reduced maintenance!
37% less service parts	smaller inventories, less expensive!



The Stopmaster 15" Brake is available with either air or hydraulic actuation . . . also up to 30" diameter, with hydraulic actuation for heavy-duty, off-highway vehicles.

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ROCKWELL-STANDARD CORPORATION

Brake Division, Ashtabula, Ohio

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alloy tin-aluminum bearings of the type used in heaviest duty industrial engines, double-lip shaft seal, hardened and ground steel gears and shafts, and high-tensile aluminum bodies. Wide variety of porting, mounting and drive arrangements are offered. Five series of pumps, with four displacement variations in each series, are available with side or end porting or combination of these, with standard SAE mounting flanges and drive shafts. Capacities range from 0.7 to 140 gpm at 2000 rpm and 2000 psi. Proof tests are reported to have been carried out at loads at least 25% higher than ratings. **Wooster Div, Borg-Warner Corp, 200 S Michigan Ave, Chicago 4.**

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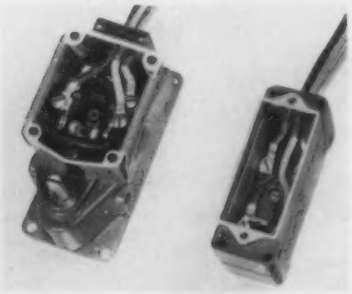

Potted limit switches . . .

are prewired, and conduit entrances are then sealed with epoxy resin. All small precision and heavy-duty limit switches can be furnished in the new design. Four No. 14 wires, 5 ft long, are standard. **Square D Co, 4041 N Richard St, Milwaukee 12.**

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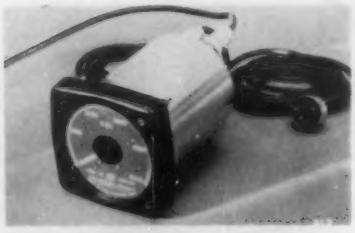

Remote-pressure indicator . . .

operates with pressure transducers having 350 strain-gage bridge with sensitivity of 3 milliv output per v excitation. Indicator has wide application in measurement of fluid and gaseous pressures, thrust, torque and similar phenomena where indication and control of measured force is required to be removed from transducer. Model consists of voltage-regulated power supply for furnishing 60 cps excitation to increase voltage level of bridge output to dc meter movement and self-contained power supply for transistor amplifier. Operates at line voltages from 105 to 125 v, 60 cps, and at temperatures from 32 to 110 F. Dials can be calibrated to any standard pressure range up to 10,000 psi. System accuracy is said to be 2% of full scale or better. Scale length is 9 in. with 100 divisions. Price, without cable or connectors, $550. **Taber Instrument Corp, N Tonawanda, NY.**

Circle 326 on Reader Service Card

Single-flapper checkvalves . . .

are lightweight units for low air-pressure applications. Typical 1.5-in. valve with aluminum body weighs ¾ lb. Single flapper is hinged to permit airflow in one direction, sealing valve opening when airflow reverses. Internal leakage is said to be less than 0.04 lb/min at 100 psi, 300 F. Available in several sizes with flanges to meet most applications. Operates in −65 to 300 F. **Barber-Colman Co, Dept PE, Rockford, Ill.**

Circle 327 on Reader Service Card

Shutoff valve . . .

for control of fluids or gases employs rotary-shear seal principle. Can be actuated by motor, solenoid, hydraulic or pneumatic energy. Flow can be positioned from zero to 10 gpm. Operating pressure is 3000 psi. Offers pressure drop of 10 psi max at full flow, low actuation torque and zero leakage. Ports are said to meet AND 10050-16 specification. **Vinson Engineering & Sales Co, 8044 Woodley Ave, Van Nuys, Calif.**

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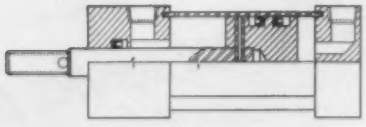

Midget air, hydraulic cylinders

offer dynamic packings, two on piston and one on rod gland. High-pressure end-cover seals are Buna-N O-rings. Aluminum pistons provide 1-in. bearing length against tube walls. Piston rods are stainless steel, ⅜ in. dia and are threaded $\frac{7}{16}$ in.-24. Number 10 tie-rods are used. Available in ¾-, 1- and 1¼-in. bores. Lengths are in 1-in. increments. In two series: for 200 psi air and 750 psi oil, and for 2000 psi oil. Operate continuously at 40 to 180 F; intermittently to 200 F. Ten heavy-duty mounting styles are offered. **Control Line Equipment, 19560 Center Ridge Rd, Cleveland 16.**

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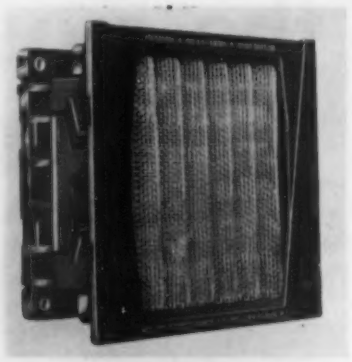

Fan with filter box . . .

that is matched to pressure-building capacity of fan provides 75 cfm filtered air, with clean filter, a drop of 25% from 100 cfm free-delivery rating of fan without filter. Filter box locks in place between grille frame and venturi fan adding slightly less than ¾ in. to over-all depth. Mounting clips, which are standard components, have second or inner station for filter fan. Filter is permanent and washable and is said to provide 80 to 85% dust arrest. **Rotron Mfg Co, Woodstock, NY.**

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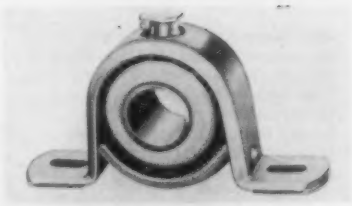

Cushioned-pillow block bearings . . .

for applications requiring noise and vibration suppression are available in shaft sizes from ¾ to 1¼ in. Series supplements smaller units introduced previously. New and larger series is also self-aligning and has large oil reservoir. Cushion, which encircles bearingball unit and insulates it from mounting, is made of 50-durometer neoprene. **Triangle Mfg Co, Oshkosh, Wis.**

Circle 331 on Reader Service Card

5-amp power transistors . . .

have 2:1 beta spreads. Intended for industrial switching-control and amplifier applications from dc through audio-frequency range. Collector-base breakdown voltages

continued on page 87

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American Brake Shoe Co.
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PUMPS • MOTORS • CONTROLS

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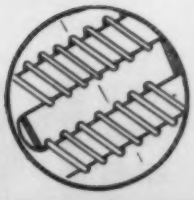
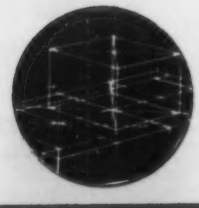
1960 ENGIN SHOW





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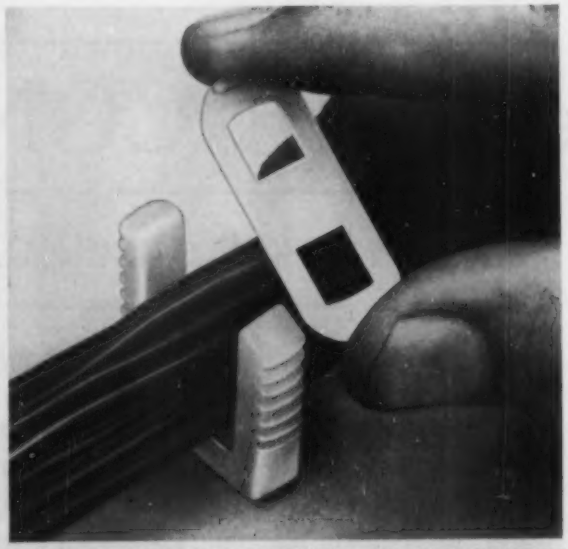

CLAMP WIRE BUNDLES IN SECONDS!

Just place wire bundle inside "U," push keeper down snugly, and this light-weight clamp is securely locked to withstand loadings greater than 50 G's! A Cab-L-Tite* clamp securing 58,000 mils weighs only 0.016 oz.; 8,570,000 mils, 0.832 oz. Proved in aircraft and missiles, Cab-L-Tite* is made of tough DuPont zytel, which meets MIL-P-17091. Removable in seconds for rerouting wires. Write for free literature. *Manufacturer of Bund-L-Tite straps.*

DAKOTA ENGINEERING, INC.

4315 Sepulveda Blvd., Culver City, California *Trade Mark

from 40 to 120 v, and measured current gains from 20 to 150 allow operation of transistors as switches at power levels up to 500 w. Transistors, in medium- and high-gain types, are germanium PNP, alloy-junction power transistors with collector common to case. Packaged in hermetically sealed, industry-standard package. Designed to meet mechanical and environmental requirements of MIL-S-19500. OEM prices range from $1.65 to $8.50 in quantities of 100 to 999. **Motorola Inc, Semiconductor Products Div, 5005 E McDowell Rd, Phoenix, Ariz.**

Circle 332 on Reader Service Card

Miniature digital readout . . . can now display words and color in addition to digits. Characters are ¾ in. high. Operates on rear-projection principle. Master condensing lens has 12 individual positions or lenses, on which are printed the desired digit, word or message in the chosen color. When lamp at rear of unit is lighted, it projects corresponding digit or color on condensing lens through projection lens onto viewing screen at front of unit. Light source comes from subminiature lamps, either No. 327, 328 or 330. Voltage is from 6 to 28 v. Dimensions of unit are 3⅜ x 1 x 1⅞ in. Weighs 3½ oz. Available from stock in single units or assemblies. Priced at $35 each. **Industrial Electronic Engineers Inc, 5528 Vineland Ave, N Hollywood, Calif.**

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Air-operated lubricating system . . . for single- or multiple-point spraying of liquids from any angle will atomize liquids with viscosity of up to 1000 SSU at 100 F. Reservoir assembly can be placed in any convenient spot; nozzle is located close to point of application. Tank capacity ranges from 2 to 5 gal. Liquid forced into spray valve is evaporated as it leaves internal spray nozzle because of high-velocity airstream surrounding it. Refrigeration effect takes place and cool spray can be used for lubricating and cooling of cutting tools or for oil lubrication

continued on page 90

Maxitorq
STANDARD
floating disc
single and double clutches
or brakes

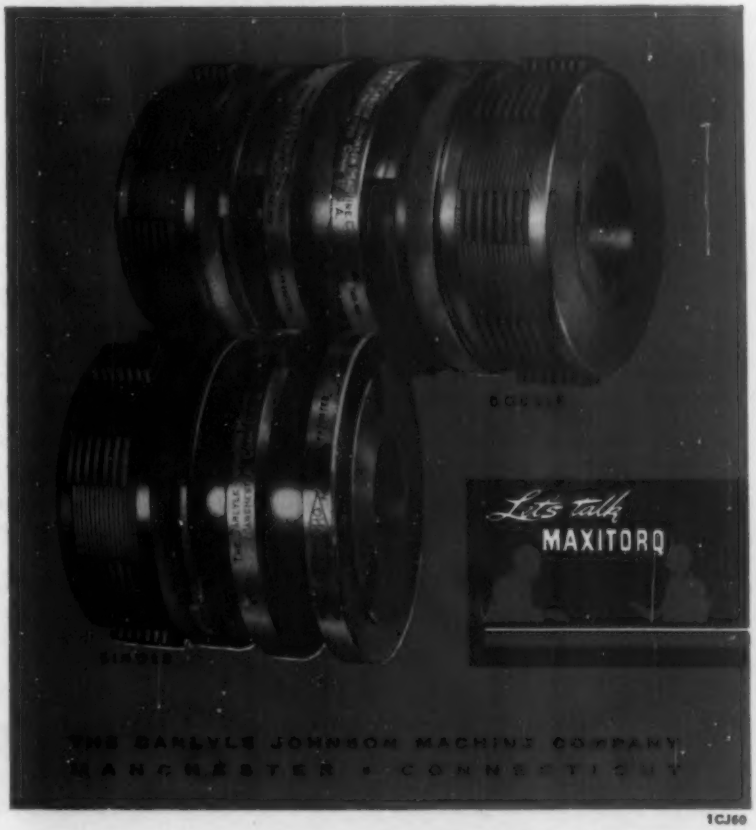
DESIGN PRINCIPLES OF THE 3 BASIC TYPES

The Maxitorq Clutch is completely assembled on the clutch body and shipped ready to slip onto a shaft. Separator springs . . . an outstanding feature . . . assure the advantages of truly floating discs. Used between each pair of inner discs, they spread them endways with an accordian action so that light can be seen between all discs when the clutch is in neutral. The floating disc feature makes certain that there's no drag . . . no abrasion . . . and consequently no heat when the clutch is in neutral.

A locking plate on the disc end of each clutch (two on the double types) locks all discs against tension developed by the separator springs. Manual adjustment is made by raising the lock spring, then turning the adjusting ring to give the desired shifting pressure.

Note that assembly adjustment and take-apart are all manual . . . no tools required.

Standard Maxitorq Clutches are available in single and double types, wet or dry . . . also in pulley and cut-off coupling types. Capacities to 15 h.p. at 100 r.p.m. Write Dept. PE for bulletin today.



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(Advertisement)

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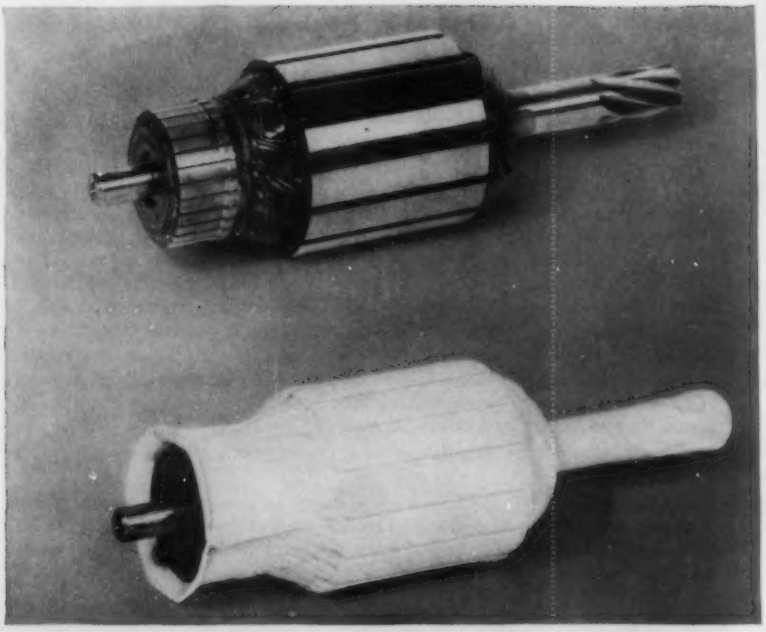


This new method of insulating electrical components utilizes thermoplastic sheet

It hasn't been called "Skinsulation" yet but it well might. It's a new method of insulating electrical components by the use of epoxy resins and a skin of thermoplastic sheet. The idea was introduced by Minnesota Mining and Manufacturing Company and its advantages are so obvious that it is bound to find a great many applications. It has been demonstrated on various types of components using "Scotch-cast" Brand Resin and Campco thermoplastic sheet.

The above photograph shows how Campco thermoplastic sheet was vacuum-formed around the component. This becomes the mold form, eliminating the steel mold. An opening is made at the top through which lead wires may be brought out. Cardboard or tape is used to hold the wires in position.

Through this same opening, the resin is poured in until the mold form is completely full. The resin reaches the most remote area insuring complete coverage. The part is then ready for curing.

Simple, isn't it? It's efficient, too, for any number of articles of varying shapes and sizes can be skin-wrapped simultaneously. The size of the vacuum-forming machine is the only limiting factor, while with the present method production is limited to the number of molds that can be used on a production cycle.

Dollarwise, there are worthwhile savings in labor and material. Where steel molds are now being used, increased production can easily be realized by making a number of vacuum molds from the master molds.

And here's another important advantage. Since by the new system production is not limited by the number of molds, presently used curing cycles may be completely changed. For example, in order to obtain three or four cycles per eight hour shift by the old method, resins must cure at 150° F. While, by the new system, a whole day's production can be cured overnight at a slower rate with the use of room curing or slower heat resins.

If you would like technical assistance or further information regarding this system, write Campco Division of Chicago Molded Products Corporation.

Garage doors decorated with Campco Butyrate

As a rule, a garage door is a rather dull and uninteresting piece of architecture. But Taylor Garage Doors, Inc., of Detroit have done something about it. Now their single and double garage doors can be decorated with numerous combinations of attractive trim in the form of shutters, windows, escutcheons, etc. Sold in kits for "do-it-yourself" application, the homeowner is provided

with the means of relief from the bare, flat planes of typical garage doors. They can be painted to match or complement the color of the door, require less repainting, and will not rot or corrode.

They are vacuum-formed by Taylor from Campco B-120 white opaque Butyrate, selected for its uniform thickness and consistent quality of whiteness.

Taylor finds that vacuum forming of Campco sheet affords an economical means of varying the designs without incurring the expense of carvings or metal stampings and finishing operations.

Received Your Campco Personal File? This data-packed reference file on thermo-plastic sheet and film is yours on request—just send name and address on Company letterhead to Campco, 2717-C Normandy Ave., Chicago 35, Illinois.

CAMPCO Sheet and Film, **a Division of Chicago Molded Products Corp.**

THERE IS A DIFFERENCE IN SOCKET SCREWS

Look at this cut-away of a forged socket cap screw from H-K. Notice the smooth, flowing lines of the metal fibers that give greater strength to the screw . . . look at the clean sockets scientifically proportioned for maximum strength . . . observe the controlled forged fillet under the screw head. These are features no other socket cap screw can match.

You won't see other features just as important to your production line: special analysis alloy steel heat-treated to 39-42 Rockwell "C" hardness . . . threads formed to Unified Class 3A fit . . . a new and different forging method that produces the toughest socket screws made . . . an atmospherically controlled hardening process. And behind all these features, the now famous SAME-DAY SERVICE on all standard catalog items!

Look for the difference in H-K socket screws . . . see the difference at your production line!

HOLO-KROME SOCKET SCREWS

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

CIRCLE 89 ON READER SERVICE CARD

(Advertisement)

SEALING UNLIMITED

by Dick Williams

The Inter-Office Memo

Some of the finest examples of modern English literature is torn up and consigned to the round file daily by our nation's businessmen. It's a great waste of national talent. I'm referring, of course, to the Inter Office Memo.

The IOM has a fleeting life but nowhere will you find humor so keen, invective so terse or sarcasm so cutting. An anthology of those succinct gems, I'm certain, would make a best seller. And in the interest of the Society for the Preservation of IOM's we intend to publish a few in these columns from time to time.

A Word About Harrison

If you are still with me, let me get in a word for Harrison Mfg. Company before we go on with the business of the Society for the P of IOM's. We make a metal-to-metal static seal of which we're justly proud. There are three configurations: Mini-Seal, AN Boss Seal and the Face Seal, all of which come in a wide variety of sizes from ¼ inch to the giant 35-inches we made recently for a classified project. That's why, in case you're wondering, we call the column what we do.

The Cure Date Problem

Here's a memo from one of our field men which illustrates the point that salesmen could be authors. (And as some bosses would say, if they don't do better at the former, they might well look for work as the latter!)

Dear Boss:

Harold and I visited a large valve manufacturer the other day. During the course of our discussion we found out that they were using our seals not because they had a temperature or pressure problem, but because they wanted to store their units for periods of time exceeding the "cure date" life of organic seals.

This was something we had pointed out to our customers before but here was a real live example. They mentioned that the cost of tearing down the hydraulic system, replacing ancient seal and rebuilding the system was far more expensive than the difference in cost between rubber and metal seals.

You know, they are right and unless mechanics strike for lower wages (perish the thought) this overhaul expense will become greater, not lesser.

Incidentally, I also talked to another customer and he mentioned that one of our seals for AND-10050 Ports, had started leaking after about 40 re-uses. (We recommend no more than 15 re-uses.) They looked at the installation and decided that the fitting had been damaged and replaced it, leaving the original seal installed.

Unless this practice is discontinued the K-Seal business will be slow this year. Boss, I am afraid that the word will get out and the only way we can keep sales up is for you to find more people who need our seals.

Sincerely, Joe

PS: You might help our salesmen out by writing for Brochures on the complete Harrison line, including our new Bolt-Head K-Seal!

HARRISON MFG. CO.
739 N. Lake Street, Burbank, California

of gears, cams or high-temperature chains. Each spray valve is equipped with one needle valve to control airflow, another to control oil flow. Spray valves produce round spray pattern. **Oil-Rite Corp, 2382 Waldo Blvd, Manitowoc, Wis.**

Circle 334 on Reader Service Card

Spline-coupled wafer pump motor . . .

mounts directly to top of reservoir with flange and pump suspended inside tank. Over-all mounting area requirements are said to be reduced about 50%. Can be used with all standard make pumps. Available in ratings from ½ through 10 hp complete with spline coupling, which connects motor shaft directly to pump. **Reuland Electric Co, Alhambra, Calif.**

Circle 335 on Reader Service Card

High-pressure hydraulic filters

with capacities of 3.5 and 10 gpm are nominally rated at 10 microns. Filter elements are made from pleated, resin-impregnated cellulose fiber sheet. Both assemblies have pressure drop of 30 psi at respective flow rates using MIL-H-5606 fluid at 100 ± 10 F. Rated for temperatures from −65 to 275 F. Heads and bowls are machined from aluminum bar stock. Rated operating pressure for both assemblies is 3000 psi with rated impulse burst pressure of 7500 psi. The 10-gpm unit weighs 1.3 lb and has 10050-10 porting; 3.5-gpm unit weighs 0.7 lb and has AND 10050-6 porting. Can also be used to filter aviation gasoline, water, alcohol, air, gaseous oxygen, lubrication oils and other related fuels. **Bendix Filter Div, Bendix Aviation Corp, 434 W 12 Mile Rd, Madison Heights, Mich.**

Circle 336 on Reader Service Card

Self-contained loading reactor

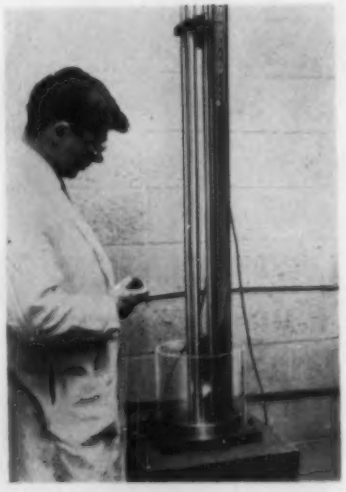
is applicable to inductive load testing in lab, research and development applications. Provides inductive load that can be made adjustable by using in conjunction with variable transformer. Used primarily for testing apparatus at various lagging power factors. Rated for 120 v, 60 cps; 2 amp at 120 v continuous duty; inductive reactance, 60 ohm; dc resistance, 4 ohm. Unit consists of gapped, strip-wound, silicon-steel toroid core, wire-wound and embedded in epoxy compound. Entire assembly is enclosed in phenolic case. Dimensions are 6 x 2⅜ x 5¾ in. Price, $35 each. Available from stock. **Superior Electric Co, Dept LR2, Bristol, Conn.**

Circle 337 on Reader Service Card

Automatic voltage regulator . . .

can also be used to obtain continuously variable voltage from 0 to 130 v ac. Primarily for industrial and laboratory use wherever constant voltage is required from varying voltage power lines. High reliability, over frequencies of 50 to 70 cps, is said to be achieved by elimination of transistors, vacuum tubes and magnetic amplifiers. Unit consists of closed-loop servo-system that automatically controls continuously adjustable autotransformer. Available in cabinet or rack-mounted models. Weighs 30 lb. **Tel-Instrument Electronics Corp, 728 Garden St, Carlstadt, NJ.**

Circle 338 on Reader Service Card

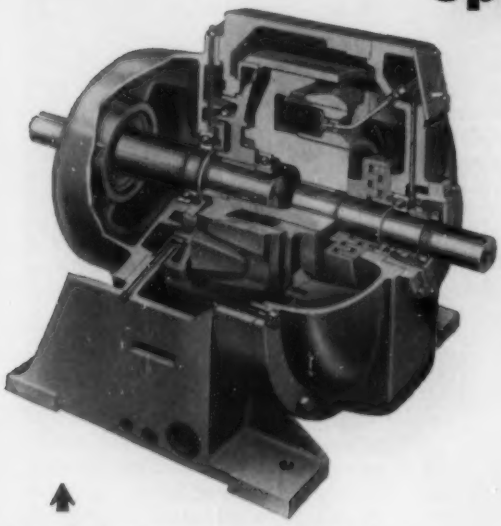


Impact tester . . .

determines shock sensitivity levels and material compatibility. Drop-weight tester with sample cup assemblies makes possible determination of shock sensitivity of solids in liquids or gases, of liquids in other liquids and gases, or the relationship between contamination and sensitivity. Machine is compact and weighs about 125 lb. Operator can stand beside machine while testing is in progress. With standard plummets, machine can test to 600 ft-lb per sq in. Requires no explosion-proof chamber. Produces up to 40 drops per hour. Test results are said to be reproducible. **Thiokol Chemical Corp, Reaction Motors Div, Denville, NJ.**

Circle 339 on Reader Service Card

The BEST Solution to Difficult Speed Control Problems—



Dynamatic Liquid-Cooled Couplings provide infinitely adjustable speeds for nearly every application from 3 to 75 HP. Note the absence of slip rings, brushes, and commutators. Heavy-duty types with capacities up to 5,000 HP are also available.

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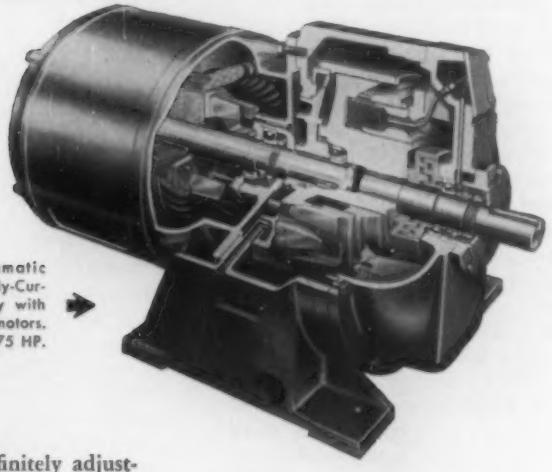

"Dynaspede" Drives are Dynamatic Liquid-Cooled, Stationary-Field Eddy-Current Couplings mounted integrally with standard, D-flange, squirrel cage motors. Available in capacities from 3 to 75 HP.

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A wide range of standard and special control features may be obtained from a remotely-mounted electronic control system. Infinite speed adjustment, constant speed control, on-off clutch control, torque limit, acceleration control, inching, and threading are a few of the many functions available. The addition of an eddy-current brake to standard couplings or drives provides smooth, cushioned stops and controlled deceleration.

Liquid-Cooled Dynamatic Couplings and Drives deliver more horsepower than other types of the same physical size, thus conserving space in a busy machine area. Efficient heat dissipation permits continued operation at low speeds, or stall with full load.

Completely enclosed, Dynamatic liquid-cooled units are protected from dust, dirt, and other atmospheric impurities. Dynamatic design involves no brushes or slip rings; there is no possibility of arcing. With simple modification these units can be made explosion-resistant for hazardous applications.

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★

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No Slip Rings, Brushes or Commutators

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DYNAMATIC DIVISION

MANUFACTURING COMPANY

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DESIGN LITERATURE

Mathematics for Engineers

W N ROSE. John F Rider Publishers Inc, 116 W 14th St, NYC, 6 x 9, 527 pp (Vol 1); 403 pp (Vol 2). $6.60 each.

The design engineer's need for mathematics is a practical one. He is not awed by the beauty of an elegant proof or captivated by tools that have no immediate applications to his work. For the most part, his reading in mathematical subjects is confined to review of once-learned techniques and study of newer, more advanced disciplines not discussed in the textbooks on his library shelf.

These two volumes will therefore not be of much use to the average engineer. They are neither a readable and condensed review, nor an up-to-date treatment of the more powerful, but infrequently used mathematical tools. The professional designer has outgrown algebra and trigonometry (the chief subject of Vol 1). Calculus and differential equations (Vol 2) are either used often enough to remember . . . or if forgotten, the designer would need only an occasional refresher, not an A to Z treatment. This he can get from a table of integrals, his college text or a handbook. The two volumes give a detailed account of the lower level math every engineer has studied. Only exceptions to this are short chapters on harmonic analysis, construction of alignment charts, solution of spherical triangles, mathematical probability.

Both volumes were originally published before 1920, this being the 9th edition of Vol 1 and the 5th edition of Vol 2. The author's preface indicates that some changes and additions have been made since the first printing, but the scope and method of presentation suggest that such revisions were probably minor. Further, the author is British (late head of the mathematics department at the Borough Polytechnic Institute in London) and the books were printed in England despite the imprint of an American publisher on their jackets. This creates some distraction for those unaccustomed to England's spelling and typography. The reader is obliged, for example, to overlook such Anglicisms as "draughtsman", "kathode", "Voltameter", "grammes" and a decimal point that floats midway between the top and bottom of characters. Even more distracting is a bindery error (in our copy, at least) in which a signature (a bundle of pages bound as a group) from Vol 2 was bound into Vol 1 in place of pages 257 to 272.

In sum: A thorough treatment of fundamental mathematics, but not one that invites readership. Good fodder for young engineers and mathematicians perhaps, but of limited value to the practicing engineer. —CJL

Rocket-propellant Handbook

B KIT, D S EVERED. Macmillan Co, 60 Fifth Ave, New York 11. 6 x 9, 354 pp. $12.50.

The handbook contains the description of nearly 100 chemicals including rocket fuels, oxidizers and monopropellants. Analysis of each substance covers: general characteristics, physical and chemical properties, methods of storing and handling, performance characteristics. Tables accompanying each entry give heat values, density at various temperatures, specific impulse and performance with alternative oxidizers or fuels. This book is an excellent reference for manufacture of handling and storage equipment, and engineers involved in the design construction of facilities.

Quality Requirement of Super-duty Steels

Edited by R W LINDSAY. Proceedings of a Technical Conference sponsored by Physical Chemistry of Steelmaking Committee of the Iron and Steel Division, and Institute of Metals Division, The Metallurgical Society, and Pittsburgh Section, American Institute of Mining, Metallurgical and Petroleum Engineers, May, '58. Interscience Publishers Inc, 250 Fifth Ave, New York 1. Vol 3. 9 x 6, 309 pp. $8.50.

No user of tool steels would think of using steel at 300,000 psi without first removing all traces of surface imperfections, decarburization or carburization. Nor would an aircraft manufacturer use bearings unless the forgings they were made from were completely machined. Whether most of the troubles from the ultrahigh-strength steel in aircraft structures come from marginal design or from material imperfections is debatable. But the harsh facts remain—steels hardened to high strengths become less ductile and more sensitive to notches and imperfections and expensive high quality in steel isn't worthwhile unless the quality is kept all the way to the final product.

Motor Selection and Application

CHARLES C LIBBY. McGraw-Hill Book Co Inc, 330 W 42nd St, New York 36. 6 x 9, 508 pp. $13.50.

This is an authoritative book that organizes, condenses, and simplifies a wealth of information to help select and apply electrical motors for industrial service. It explains motor selection in terms of load characteristics, service requirements, and safety. Charts, tables and illustrations relate these load variables to motor characteristics, enabling the engineer to achieve the most economical, smallest, lightest, and lowest maintenance electrical equipment for the mechanical task to be performed.

ABSTRACTS FROM THE LITERATURE

Design of Injection Moldings

Such design considerations as strength of moldings, maintenance of constant wall thickness, ribs and webs, bosses for fasteners, parting lines are discussed and illustrated with many free-hand sketches.

"The Design of Injection Moldings," W. Bruce Brown. Plastics, March '60, Bowling Green Lane, London, E C 1, England.

Design of Molded Polyolefin Parts

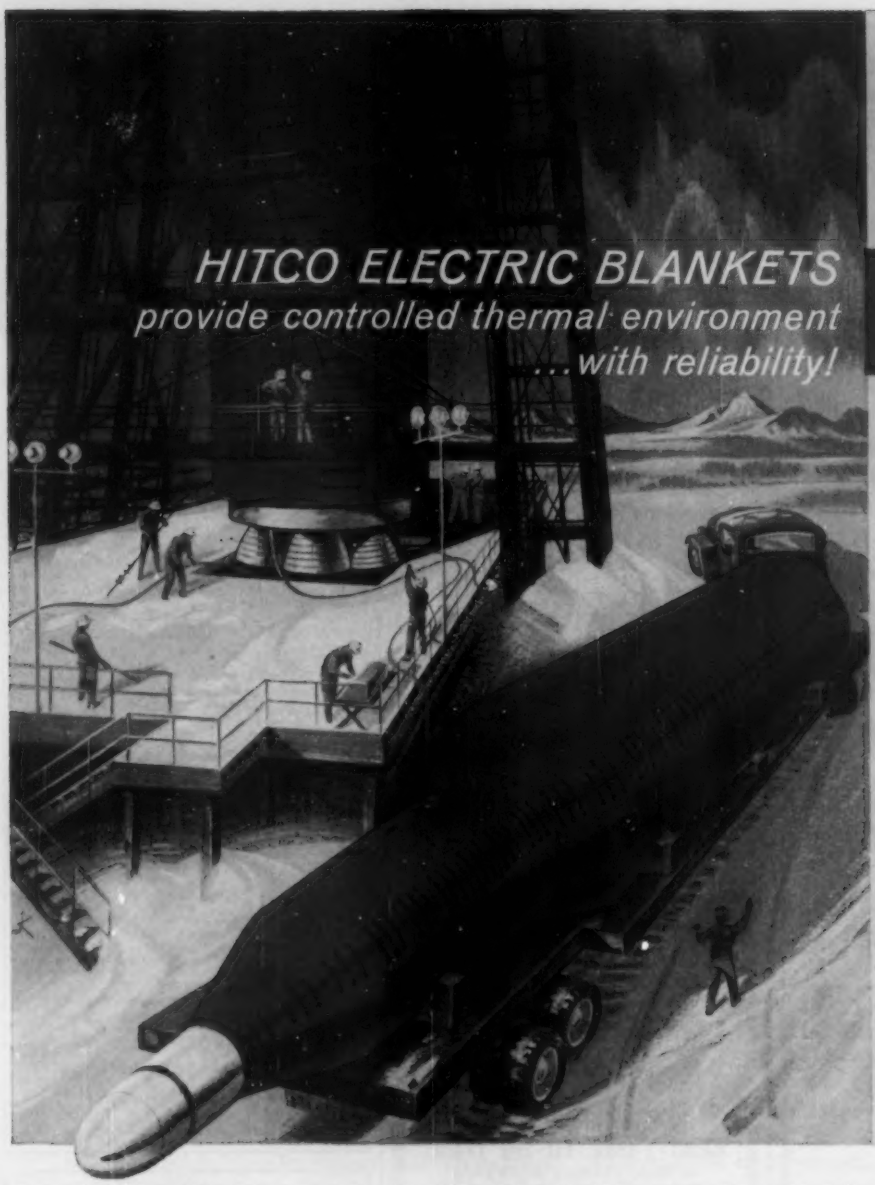
Means of improving rigidity and eliminate warping, geometry that simplifies production of flat items, design suggestions for containers and box-like items, sidewall and edge design are all illustrated and described.

"Design Considerations for Molded Polyolefin Items," Scott, Smith and Alexander, Phillips Chemical Co. SPE paper 19-1, Society of Plastics Engineers Inc, 65 Prospect St, Stamford, Conn.

Do Standards Stifle Creativity?

In this discussion of the interrelationship among engineering creativity and standardization of procedures, components and other design factors, various authorities are cited and their findings and opinions evaluated. In a listing at the end of the article, the

continued on page 97



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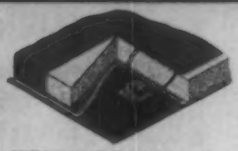
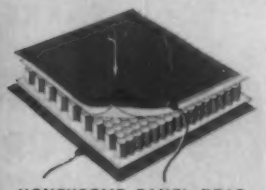


CUTAWAY VIEW. Shows Heating Element of HITCO Electric Blanket—sealed between cover and inner cover.



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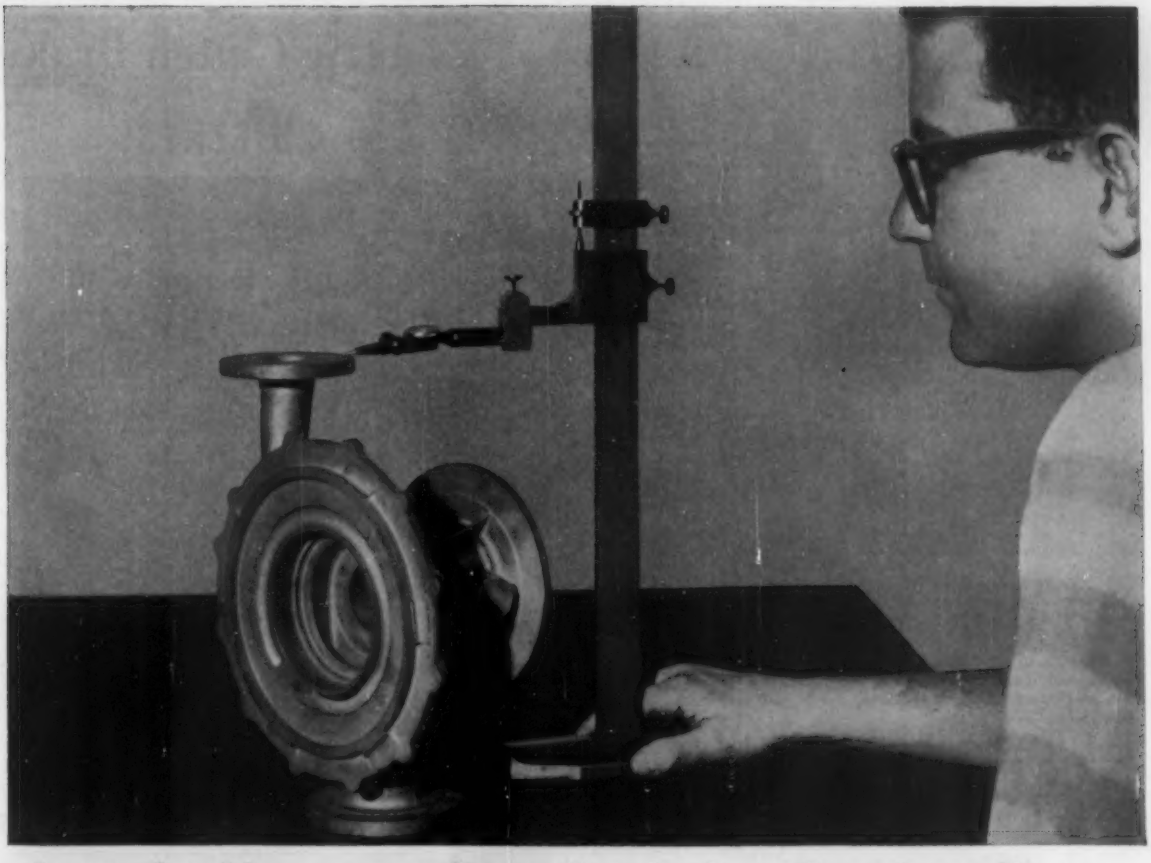

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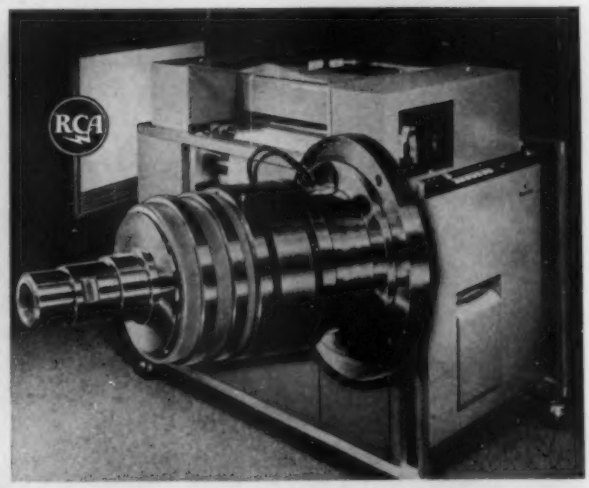

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principal characteristics of the engineering work involved in various activities (such as applied research, R & D for a specific product, quantity production) are presented.

"Standardization and Creativity," Rowen Gile, W. L. Maxson Corp. Magazine of Standards, March '60, 10 E 40 St, New York 16.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 101.

INDUSTRIAL V-BELT DESIGN—Catalog, 64 pp. Presents general information on V-belt drives, drive-selection tables, hp-rating tables and matching data, and product information. Boston Woven Hose & Rubber Div, American Biltrite Rubber Co Inc, Box 1071, Boston 3.

Circle 350 on Reader Service Card

ELECTRONIC BUYING GUIDE—Purchasing guide, 1960, 256 pp. Lists more than 6000 manufacturers, as well as representatives, products and services. Representatives section is primarily western. Roster of US Missile and Rocket Program gives current status of each project. Directories of Industry Inc, Dept M-1, 2225 Southwest Dr, Los Angeles 43.

Circle 351 on Reader Service Card

ALUMINUM JOINING—Manual, 40 pp. Covers aluminum welding, brazing and soldering. Contains 12 charts on composition of aluminum alloys, their technical and physical properties, recommended filler alloys for MIG and TIG welding. Aluminum joining products and fluxes are included with Government specifications covered by alloys. All-State Welding Alloys Co Inc, 249-55 Ferris Ave, White Plains, NY.

Circle 352 on Reader Service Card

PRINTED CIRCUITS—Booklet, 16 pp. Outlines several functions that may be performed by printed wiring board and describes types of circuitry best adapted to this type of construction. Also discusses materials, construction and design. Arthur Ansley Mfg Co, New Hope, Penna.

Circle 353 on Reader Service Card

ELECTRIC-MOTOR OPERATORS AND MOTORIZED VALVES—Catalog 407, 24 pp. Describes features, construction, applications and mounting positions. Gives specifications, ratings and dimensional information. Schade Valve Mfg Co, 2527 N Bodine St, Philadelphia 33.

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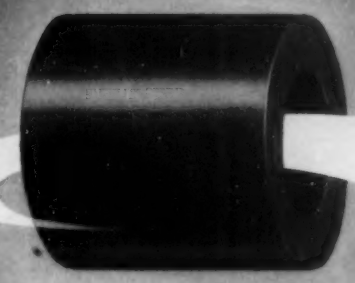

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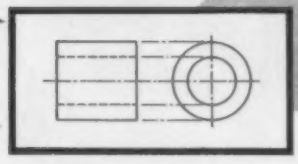

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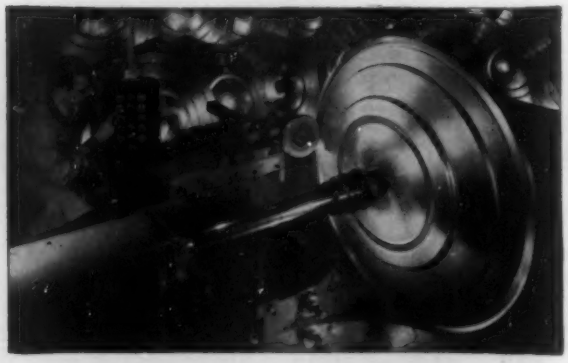

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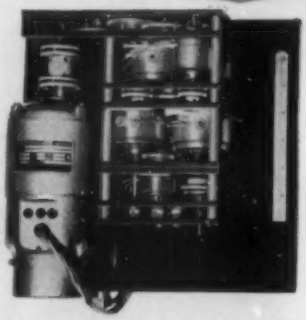

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HARDNESS-CONVERSION CHART – Data card 183. Chart shows approximate relation between hardness by various testing systems and tensile strength of carbon and alloy steels. Hardness systems covered are Brinell, Monotron, Vickers, Rockwell and Scleroscope. Tubular Products Div, Babcock & Wilcox Co, Beaver Falls, Penna.

Circle 355 on Reader Service Card

PHYSICAL DATA, CONSTANTS AND CONVERSION FACTORS – Booklet PIBD-1, 24 pp. Physical data on sun, planets and major satellites of solar system for use in preliminary design of space vehicles. Also provides information and calculator for computation of trajectories of ballistic missiles and orbiting rockets. Missile and Space Vehicle Dept, General Electric Co, 3198 Chestnut St, Philadelphia 4.

Circle 356 on Reader Service Card

STANDARD CANNON PLUGS–Catalog, 16 pp. Outlines applications, performance information, sizes and ratings of principal units. With illustrations. Schweber Electronics, 60 Herricks Rd, Mineola, NY.

Circle 357 on Reader Service Card

MAGNETIC CONTACTORS AND STARTERS–Bulletin GEA-7020, 20 pp. Describes and illustrates contactors and starters, with product features, application and installation information, and specifications. General Electric Co, Schenectady 5.

Circle 358 on Reader Service Card

SHAFT-POSITION DIGITAL ENCODERS–Brochure, 12 pp. Gives specifications of 13- and 8-bit and incremental encoders. Describes operating principle of magnetic readout. Table is included for conversion from binary to decimal or Gray codes. Ascop Div, Electro-Mechanical Research Inc, PO Box 44, Princeton, NJ.

Circle 359 on Reader Service Card

RACK-AND-PANEL CONNECTORS–Sound-slide film. Describes line of advanced miniature electrical connectors, how they operate, and how they are installed. Generally covers subject of self-aligning rack-and-panel electrical connectors. Deutsch Co, Electronic Components Div, Municipal Airport, Banning, Calif.

Circle 360 on Reader Service Card

ENGINEERED IRON CASTINGS–Brochure, 12 pp. Presents facilities and services used in production of castings from wide range of iron alloys. Also contains comparative-properties chart and descrip-

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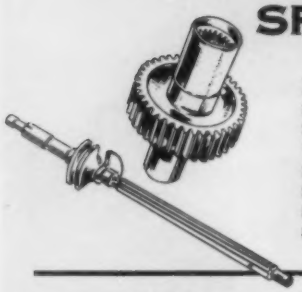

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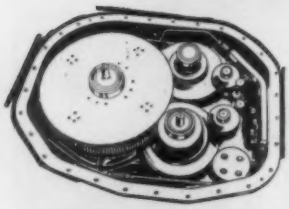

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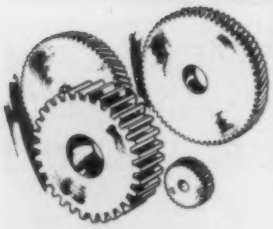

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STOCK INDUSTRIAL PLASTICS–Bulletin, 12 pp. Contains property and application information on mill shapes of nylons, TFE fluorocarbons, polycarbonates, chlorinated polyethers and cross-linked polystyrene. Also includes information on nylon pressure hose and tubing. Polymer Corp of Penna, 2140 Fairmont Ave, Reading, Penna.

Circle 362 on Reader Service Card

LIQUID-SPRING SHOCK ABSORBERS –Handbook CH, 12 pp. Illustrates and describes operation of liquid-spring shock absorbers with nomographs and formulas. Presents typical applications and standard models. Taylor Devices Inc, North Tonawanda, NY.

Circle 363 on Reader Service Card

RELAYS–Bulletin GEA-7021, 12 pp. Discusses line of relays and their applications. Contains dimensions, ratings, ordering and installation information. General Electric Co, Schenectady 5.

Circle 364 on Reader Service Card

RIGHT-ANGLE MOTOR CONTROLS –Brochure, 6 pp. Defines principle of right-angle design and explains operational principle. Covers design and construction features of starters and contactors. Arrow-Hart & Hegeman Electric Co, Industrial Control Div, 103 Hawthorne St, Hartford 6, Conn.

Circle 365 on Reader Service Card

PRESSURE-MEASURING ELEMENTS –Catalog 900, 16 pp. Describes and illustrates diaphragm and Bourdon tube elements, characteristics of standard measuring elements and dimensions. Also includes specifications, materials and performance information. US Gauge Div, American Machine and Metals Inc, Sellersville, Penna.

Circle 366 on Reader Service Card

LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

METAL POWDERS–Directory, 22 pp. Covers all types of powders produced by 29 companies for use primarily in powder metallurgy. Metal Powder Producers Assoc, 60 E 42nd St, New York 17.

PRECISION-GROUND GEARS–Booklet, 12 pp. Describes and illustrates new methods, facilities and applications for hardened and precison-ground gears. Philadelphia Gear Corp, Schuylkill Expressway, King of Prussia, Penna.

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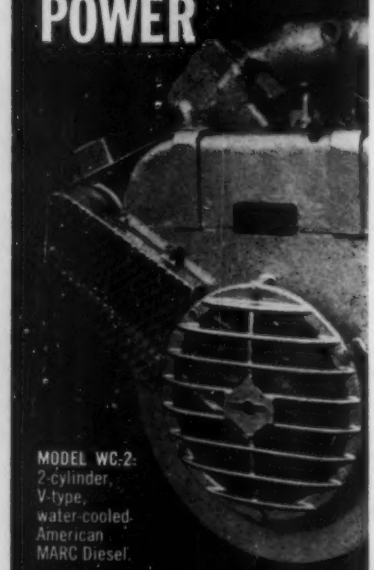

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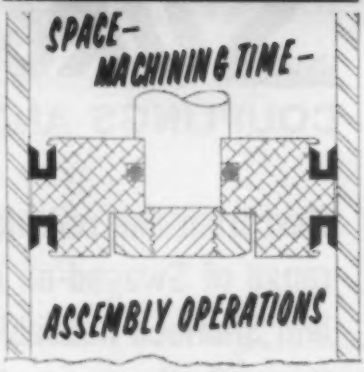

Now widely used where cup or V-packings were required, Palmetto U-Rings are effecting important savings for designers and builders of hydraulic and pneumatic equipment. Their compactness, versatility, strength and durability permits the use of simple, one-piece pistons . . . eliminates glands, backing plates, and their accessory fittings. Savings in space, machining time, and assembly operations are obvious.

Palmetto U-Rings seal with extremely low friction. There is no opportunity for binding due to over compression. Rugged, rectangular design Palmetto U-Rings (greater height than cross-section width), are more stable than square rings, resist rolling or twisting in piston groove.

Palmetto fabric reinforced U-Rings are available for use where clearances are larger, pressures are higher, or greater strength is required, as in hydraulic service . . . Also available in homogenous rubber for use where clearances are smaller and where pressures are below 500 psi, as in air service. Both styles are designed to snap over a retaining lip and into the packing groove of simple one piece pistons.

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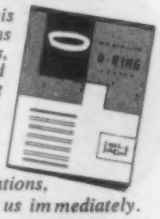

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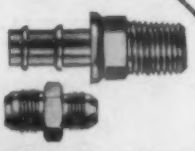

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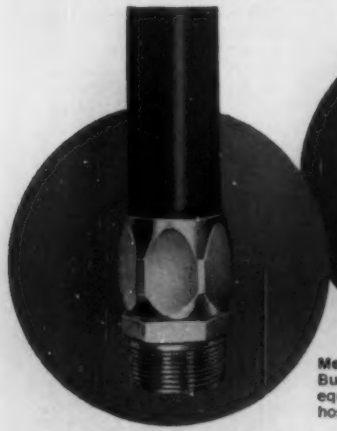

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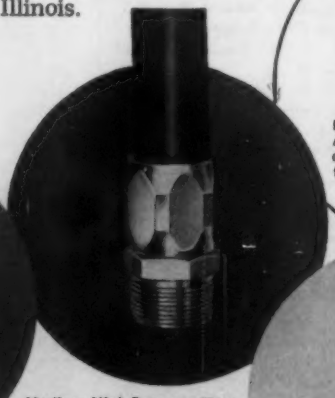
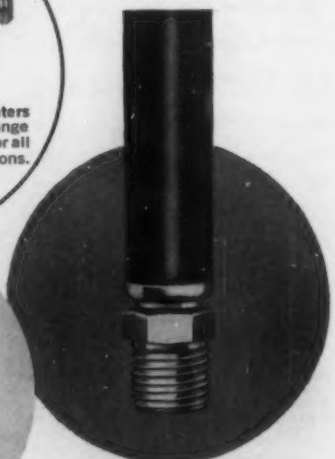


Medium High Pressure Hose. Burst and working pressure equivalent to SAE 100R1. In hose ID's from 3/16" to 1 13/16".

Medium Pressure Hose. Complies with SAE 100R3 requirements. In hose ID's from ¼" to 1".



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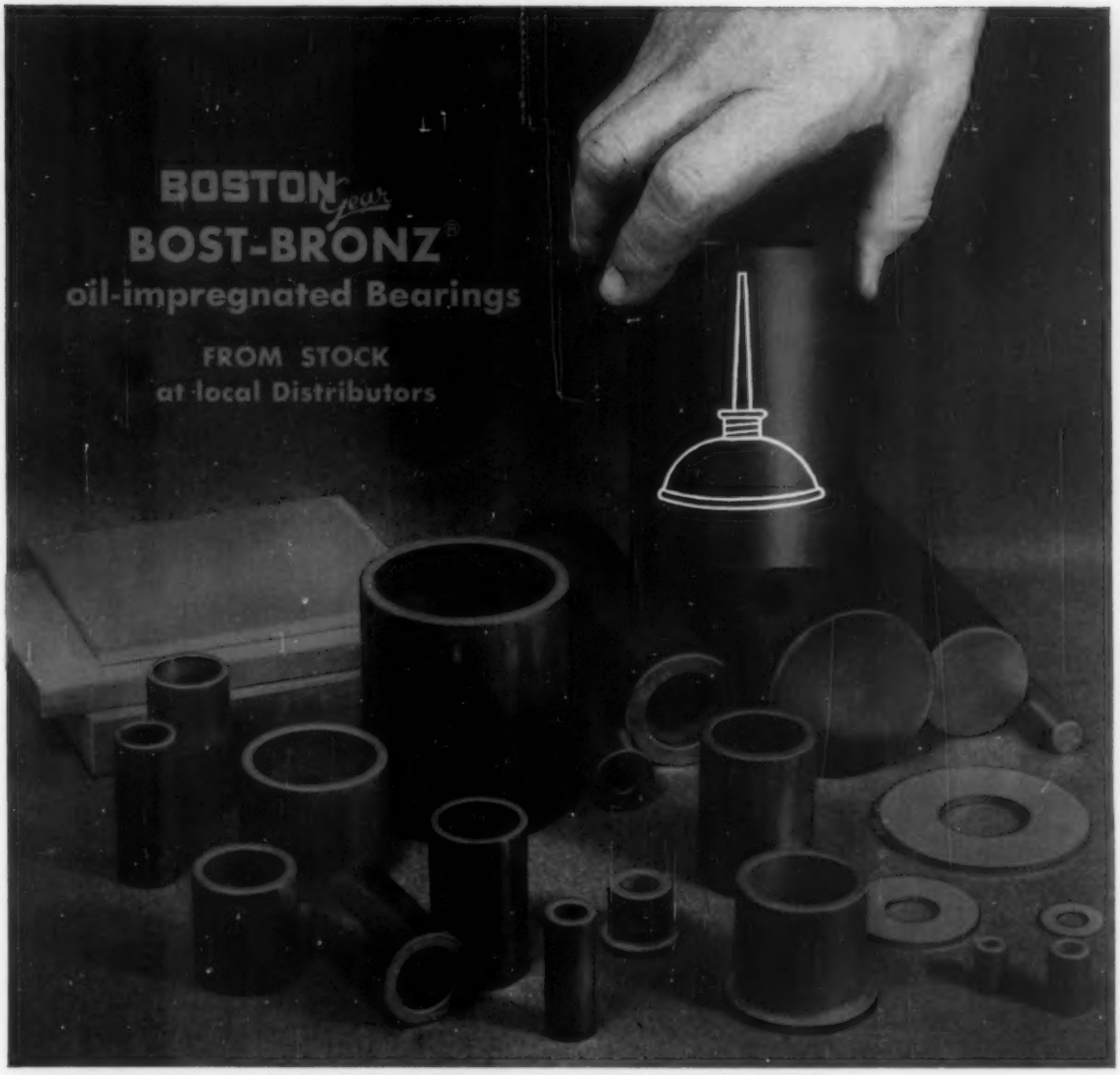

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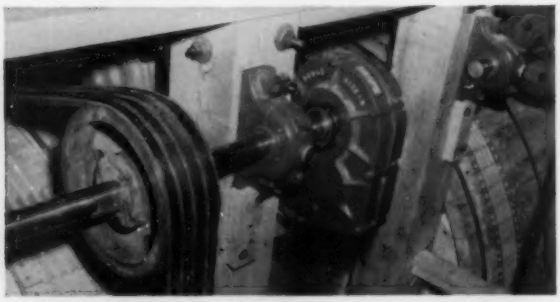
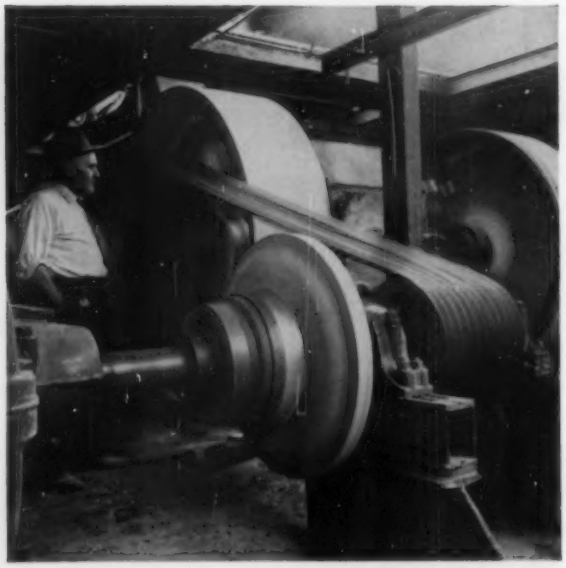
CIRCLE 202 ON READER SERVICE CARD

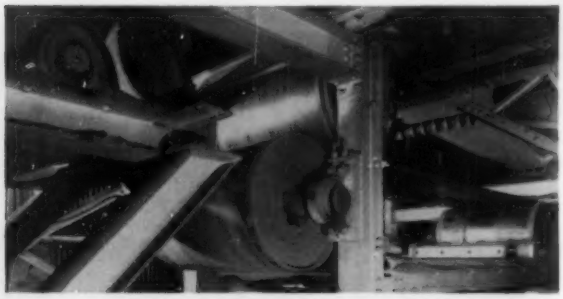
How Dodge pillow blocks with Timken® bearings give longer life with less maintenance



1. Two 2⅞" Dodge Special Duty pillow blocks equipped with Timken® tapered roller bearings, support the line shaft driving six by eight foot tanning drums. The tapered design of Timken bearings enables them to take both radial and thrust loads in any combination.



2. The crusher at a trap rock and asphalt plant runs faster, gives more production now that Dodge Double Interlock pillow blocks on Timken bearings are installed. The Timken bearings in these blocks give full-line contact between rollers and races for greater load carrying capacity.



3. The Timken bearings in All-Steel Dodge pillow blocks must stand up under adverse operating conditions found when sintering metals. One major advantage of Timken tapered roller bearings is their ability to hold housings and shafts concentric, thus keeping lubricant in, dirt and dust out.

The photo at right shows the Dodge All-Steel pillow block Timken bearing equipped. The specially designed bearing has a tapered bore with self-aligning spherical outer surface—never needs adjustment.

There's a Dodge pillow block equipped with Timken bearings to fill every engineering need: All-Steel, Type "E", Double-Interlock, Type "C" and Special Duty. And with Timken bearings, space consuming thrust devices are not needed. Look for Timken bearings in all the machines you buy or build. They're the symbol of quality. The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.

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